DOCUMENT RESUME

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DESCRIPTORS Aviation Mechanics: *Aviation Technology; Behavioral Objectives: *Computers: Course Descriptions: Curriculum Guides: *Electromechanical Technology: Engines: *Equipment Maintenance: High Schools; Navigation: Postsecondary Education: Programed Instructional Materials: *Repair; Secondary Education: Technical Education: Textbooks; Workbooks

IDENTIFIERS Aircraft: *Avionics: Instrument Mechanics; *Instrument Repairers: Military Curriculum Project

ABSTRACT

This high school-postsecondary-level course for avionics instrument systems specialist is one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. A plan of instruction outlines five blocks of instruction (281 hours of instruction). Block 1, Aircraft Maintenance Fundamentals, includes programmed tests, handout, and workbook on four topics: Aircraft Familiarization, Avionics Safety, Avionics Maintenance Fundamentals, Pressure Sensors. Block 2, Engine Instruments, contains programmed texts, workbooks, and handouts on nine topics: Position Indicating Systems, Pressure Indicating Systems, Tachometer Systems, Temperature Indicating Systems, Fuel Flow Indicating Systems, Engine Pressure Ratio Indicating Systems, Resistance-Type Liquid Quantity System, Capacitance Liquid Quantity System, Vertical Scale Engine Instrument Systems. Block 3, Flight Instruments, contains programmed texts, workbooks, handouts, and worksheets on five topics: Pilot-Static Systems and Instruments, Automatic Altitude Reporting System, Accelerometers, Flight Data Recorders, Air Data Computer Systems and Vertical Scale Flight Instruments). Block 4, Integrated Flight and Navigational Instruments, includes programmed texts, workbooks, and handouts of five topics: Flight Instruments, Direct Reading, Altitude Heading Reference and Gyro Stabilized Magnetic Compass Systems, MC-1 Compass Calibration. Block 5, Flight Director Systems, contains a programmed text, handouts, and workbook. (YLB)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

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Military Curriculum Materials for Vocational and Technical Education

Information and Field
Services Division

The National Center for Research
in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

Classroom Course 2-7

AVIONICS INSTRUMENT SYSTEMS SPECIALIST
C3ABR32531

Developed by:

United States Air Force

Development and Review Dates:

October 31, 1978

Occupational Area:

Aviation

Target Audiences:

Grades 11 - Adult

Print Pages:

2120

Availability:

Vocational Curriculum Coordination Centers

Contents:	Type of Materials:						Instructional Design:				Type of Instruction:	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
BLOCK I - Aircraft Maintenance Fundamentals	•	•	•	•		X	•		•		•	•
BLOCK II - Engine Instruments	•	•	•	•		X	•		•		•	•
BLOCK III - Flight Instruments	•	•	•	•		X	•		•	•	•	•
BLOCK IV - Integrated Flight and Navigational Instruments	•	•	•	•		X	•		•	•	•	•
BLOCK V - Flight Director Systems	•	•	•	•		X	•		•		•	•

X Materials are recommended but not provided.

THE NATIONAL CENTER
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The Ohio State University

1960 Kenny Road
Columbus, Ohio 4321
(614) 486-3655

2 AVIONICS INSTRUMENT SYSTEMS SPECIALIST
C3ABR32531

Course Description

This course is designed to train students to perform duties as an Avionics Instrument Systems Specialist. It includes operational checks, adjustments, minor repairs, periodic inspections, and line and shop maintenance of instruments and instrument systems necessary for the operation and navigation of aircraft. Emphasis is given to basic troubleshooting procedures, adjustment, and calibration of engine instruments, fuel flow and liquid quantity indicating systems, air pressure operated flight instruments, electronic/transistorized central air data computers, gyro operated flight instruments, magnetic compasses and flight directors. This course is divided into five blocks containing 281 hours of instruction.

Block I - Aircraft Maintenance Fundamentals contains four lessons covering 32 hours of instruction. Printed materials include six programmed texts, one handout, and one workbook. Lesson topics are:

Aircraft Familiarization
Avionics Safety
Avionics Maintenance Fundamentals
Pressure Sensors

Block II - Engine Instruments contains nine lessons covering 74 hours of instruction. Printed materials include nine programmed texts, nine workbooks, and two handouts. Lesson topics are:

Position Indicating Systems
Pressure Indicating Systems
Tachometer Systems
Temperature Indicating Systems
Fuel Flow Indicating Systems
Engine Pressure Ratio Indicating Systems
Resistance-Type Liquid Quantity System
Capacitance Liquid Quanity System
Vertical Scale Engine Instrument Systems

Block III- Flight Instruments contains five lessons covering 73 hours of instruction. Printed materials include eight programmed texts, five workbooks, four handouts, and one worksheet. Lesson topics are:

Pitot-Static Systems and Instruments
Automatic Altitude Reporting System
Accelerometers
Flight Data Recorders
Air Data Computer Systems and Vertical Scale Flight Instruments

Block IV - Integrated Flight and Navigational Instruments contains five lessons covering 74 hours of instruction. Printed materials include six programmed texts, five workbooks, and two handouts. Lesson topics are:

Flight Instruments
Direct Reading
Attitude Heading Reference and Gyro Stabilized Magnetic Compass Systems
MC-1 Compass Calibration

Block V - Flight Director Systems contains one lesson covering 28 hours of instruction. Printed materials include one programmed text, two handouts, and one workbook.

AVIONICS INSTRUMENT SYSTEMS SPECIALIST CLASSROOM COURSE
C3ABR32531

TABLE OF CONTENTS

Block Page

I. Aircraft Maintenance Fundamentals

Aircraft Familiarization 55
Avionics Safety 165
Avionics Maintenance Fundamentals 221
Pressure Sensors (Materials found in Unit 103) 55

II. Engine Instruments

Position Indicating Systems 432
Pressure Indicating Systems 604
Tachometer Systems 682
Temperature Indicating Systems 717
Fuel Flow Indicating Systems 774
Engine Pressure Ratio Indicating Systems 818
Resistance-Type Liquid Quantity System 859
Capacitance Liquid Quantity System 889
Vertical Scale Engine Instrument Systems 951

III. Flight Instruments

Pitot-Static Systems and Instruments 1066
Automatic Altitude Reporting System (AIMS) 1233
Accelerometers 1319
Flight Data Recorders 1348
Air Data Computer Systems and Vertical Scale Flight Instruments 1368

IV. Integrated Flight and Navigational Instruments

Flight Instruments 1531
Direct Reading (Standby Compass 1630
Attitude Heading Reference and Gyro Stabilized Magnetic Compass 1672
MC-1 Compass Calibration 1817
Electronic Test Equipment 1888
V. Flight Director Systems 1943

UNAVAILABLE MATERIALS

The following materials were unavailable from the Air Force:

3ABR32531-HO-301, Pitot-Static System Schematic
TO5F5-2-27-2, Maximum Safe Speed Airspeed Indicating System
TO5F8-9-10-2, Altitude Vertical Speed Indication System
TO 1F-111 (B)A-06, Aircraft Maintenance Work Unit Code Manual
TO 5N3-3-71, Magnetic Compass Calibrator Set (MC-1)
3ABR32531-WB-405 (403A) Bench Check AFRS Electronic Components

POI C3ABR32531 000
(PDS Code KCL)

PLAN OF INSTRUCTION
(Technical Training)

AVIONICS INSTRUMENT SYSTEMS SPECIALIST

CHANUTE TECHNICAL TRAINING CENTER

31 October 1978-Effective 31 October 1978 with class 780905

b

DEPARTMENT OF THE AIR FORCE
Chanute Technical Training Center (ATC)
Chanute Air Force Base, Illinois 61868

PLAN OF INSTRUCTION C3ABR32531 000
(PDS Code KCL)
31 October 1978

FOREWORD

1. PURPOSE: This publication is the plan of instruction (POI) when the pages shown on page A are bound into a single volume. The POI contains the qualitative requirements for course C3ABR32531 000, Avionics Instrument Systems Specialist, in terms of criterion objectives for each unit of instruction and shows time, training standard correlation, and support materials and guidance. When separated into units of instruction, it becomes the lesson plan/Part I. This POI was developed according to AFR 50-8, Instructional System Development, and ATCR 52-6, Curriculum Documentation.

2. COURSE DESIGN/DESCRIPTION: The instructional design for this course is Group/Lock Step. Training consists of technical training and military training. In technical training, the course trains airmen to perform duties prescribed in AFR 39-1 for Avionics Instrument Systems Specialist, AFSC 32531. It includes operational checks, adjustments, minor repairs, periodic inspections, and line and shop maintenance of instruments and instrument systems necessary for the operation and navigation of aircraft. Fundamentals of electronics, the physics of mechanical systems, and physics of the atmosphere are also included. Emphasis is given to basic troubleshooting procedures, adjustment, and calibration of engine instruments, fuel flow and liquid quantity indicating systems, air pressure operated flight instruments, electronic/transistorized central air data computers, gyro operated flight instruments, magnetic compasses and flight directors. The operation and use of test equipment, such as air pressure operated barometers and manometers, electric meters, and special test sets that are used for checking and calibrating instruments and instrument systems are covered. In addition, military training is provided on driver education, troop information program, commander's calls, and physical conditioning, etc.

3. REFERENCES: This POI is based on Specialty Training Standard, 325X1, March 1977, and Course Chart C3ABR32531 000, 12 October 1978.

FOR THE COMMANDER

NORMAN E. MINER, JR., Colonel, USAF
Commander, 3360 Technical Training
Group

Supersedes Plan of Instruction C3ABR32531 000, 1 September 1978.
OPR: 3360 Technical Training Group
DISTRIBUTION: Listed on Page A

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Avionics Instrument Systems Specialist

BLOCK TITLE

Aircraft Maintenance Fundamentals

1. COURSE CONTENT	2. TIME
3. Aircraft Familiarization	4

Without reference, select facts concerning aircraft

a. structural areas and systems. STS: 9c Meas: W

b. principles of flight and functions of flight controls. STS: 9b Meas: W

c. types and distinguishing characteristics. STS: 9a Meas: W

Note: Units 101 and 102 have been omitted because of military specific materials.

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SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	I	103	31 October 1978	5

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-103, Aircraft Familiarization
3ABR32531-HO-100

Audio Visual Aids
Transparencies, Aircraft Familiarization

Training Methods
Lecture/Discussion (4 hrs)

Instructional Guidance
Using HO-100 and transparencies, discuss aircraft familiarization. Stress types and distinguishing characteristics, principles of flight, flight controls, and structural areas and systems.

9

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE

Aircraft Maintenance Fundamentals

1. COURSE CONTENT	2. TIME
4. Avionics Safety	2

Without reference, select statements concerning:

a. Principles and objectives of ground safety. STS: 3a Meas: W

b. Precautions around aircraft danger areas. STS: 3g Meas: W

c. Principles of hazards of high intensity sound and protective measures. STS: 3b Meas: W

d. Facts about marking of radioactive parts and material. STS: 3d Meas: W

e. Facts about radiation hazards. STS: 3f Meas: W

f. FOD control. STS: 3h Meas: W

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SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	I	104	31 October 1978	7

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10

COURSE CONTENT

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-104 (105), Avionics Safety
3ABR32531-HO-100

Audio Visual Aids
Transparency, Safety

Training Methods
Lecture/Discussion (2 hrs)

Instructional Guidance
Discuss avionics safety, insuring that the students realize the importance of safety. Point out that safety is an integral part of maintenance and will be stressed in future lessons when applicable.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Avionics Instrument Systems Specialist

BLOCK TITLE
Aircraft Maintenance Fundamentals

1. COURSE CONTENT	2. TIME
5. Avionics Maintenance Fundamentals	24
Without reference, select statements pertaining to:	
a. Protection of exposed electrical connectors and open pressure lines. STS: 10h Meas: W	(1)
b. Removing and installing components. STS: 10g Meas: W	(2)
c. Corrosion control. STS: 10e Meas: W	(2)
d. Use of aircraft hardware. STS: 10a Meas: W	(6)
e. Care and use of handtools. STS: 10f Meas: W	(3)
f. Given a handtool trainer, handtools, and a torque wrench, torque bolts to specified values in accordance with procedures listed in the applicable workbook to obtain an accuracy of 100%. STS: 3c, 3e, 10f Meas: P	(1)
g. Given a handtool trainer, handtools, and materials, accomplish safety wiring projects in accordance with procedures listed in the applicable workbook to obtain an accuracy of 100%. STS: 3c, 3e, 10c, 10f Meas: P	(4)
h. Given handtools, soldering iron and materials, demonstrate soldering skills in accordance with procedures listed in the applicable workbook to obtain an accuracy of 100%. STS: 3c, 3e, 10b, 10f Meas; P	(3)
i. Given handtools, crimping device, and materials, attach solderless connectors to electrical wires in accordance with procedures listed in Part II, Exercise I and IV of the programmed text to obtain an accuracy of 100%. STS: 3c, 3e, 10d, 10f Meas: P	(2)

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SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	I	105	31 October 1978	9

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-105, Maintenance Fundamentals
3ABR32531-PT-105A, Aircraft Hardware
3ABR32531-PT-105B (108), Care and Use of Handtools
(Supplement for 3ABR32531-PT-105B)
3ABR32531-PT-105C, Special Tools, Safetying Devices, Soldering Techniques and Solderless Connectors
3ABR32531-WB-105, Special Tools, Safetying Devices, Soldering Techniques and Solderless Connectors
3ABR32531-HO-100

Audio Visual Aids
AVA 501, Soldering and Soldering Iron Preparation
AVA 502, Stripping and Crimping
Transparencies, Avionic Maintenance Fundamentals

Training Equipment
Trainer, Handtool (1)
Trainer, Hardware (6)
Handtools Set (1)
Torque Wrench (1)
Soldering Iron (1)
Crimping Tool (1)
Safety Goggles (1)

Training Methods
Lecture/Discussion (14 hrs)
Demonstration/Performance (10 hrs)

Multiple Instructor Requirements
Safety, Equipment, Supervision (2)

Instructional Guidance
Using transparencies and trainers, discuss maintenance fundamentals. Stress the importance of using the proper hardware and tools for the job. Provide students with required instructional materials. Insure training equipment is available and operable. Use Hardware Trainer for clarification of stated objective. Answer students' questions and give assistance where needed. Insure safety standards are maintained in the lab.

MIR: One instructor can monitor 6 students.

13

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Avionics Instrument Systems Specialist
BLOCK TITLE Aircraft Maintenance Fundamentals	

1. COURSE CONTENT	2. TIME
11. Pressure Sensors	2

a. Without reference, select statements concerning the operation of pressure sensors. STS: 15a Meas: W

(1) Bourdon Tube

(2) Diaphragm

(3) Aneroid

(4) Bellows

Note: Units 106 - 110 have been omitted
because of military specific materials.

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	I	111	31 October 1978	21

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-HO-100

Audio Visual Aids
Transparencies, Pressure Sensors

Training Methods
Lecture/Discussion (2 hrs)

Instructional Guidance
Using transparencies discuss pressure sensors used in aircraft instrumentation. Point out that a good understanding now will aid them throughout the remainder of the course. After all objectives have been met, collect all reusable student materials.

12	Military Training	5
	a. Physical Conditioning	(4)
	b. Commander's Call	(1)
13.	Written Test and Critique	2

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE

Engine Instruments

1. COURSE CONTENT	2. TIME

NOTE: The standard of performance for all knowledge criterion objectives is the passing score on the written test.

1. Position Indicating Systems 5

a. Without references, select statements pertaining to the operation of typical position indicating systems. STS: 12a Meas: W

b. Given a workbook and trainers, perform an inspection and operational check of position indicating systems with an accuracy of 100% correct workbook responses. STS: 3e, 12b Meas: P

c. Given a workbook, test equipment and trainers, troubleshoot the position indicating systems with an accuracy of 100% workbook responses. STS: 3e, 12c, 12e Meas: P

d. Given a workbook, test equipment and trainers, bench check components of a position indicating system with an accuracy of 100% workbook responses. STS: 3e, 12d, 12e Meas: P

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	201	31 October 1978	23

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-201, Position Indicating Systems
3ABR32531-WB-201 Inspection, Operational Check, Troubleshooting, and Bench Check of Position Indicating Systems
3ABR32531-HO-200 Engine Instruments

Audio Visual Aids
Transparencies, Position Indicating Systems

Training Equipment
Trainer, Wheel Position Indicating System (2)
Trainer, Flap Position Indicating System (2)
Multimeter (2)

Training Methods
Lecture/Discussion (3 hrs)
Performance (2 hrs)

Multiple Instructor Requirements
Safety, Equipment, Supervision (2)

Instructional Guidance
Using transparencies, discuss position indicating systems. Provide students with all required instructional materials. Provide assistance to the student in the laboratory stations as required. Insure safety standards are maintained and certify attainment of the criterion objectives. Where feasible, shut off operating equipment and/or trainers during breaks. This applies to all lessons in this block. Also instruct all students to use CAUTION and follow directions listed for all toxic or caustic solutions.

MIR: One instructor can monitor 6 students during 2 hours of performance.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Avionics Instrument Systems Specialist

BLOCK TITLE
Engine Instruments

1. COURSE CONTENT	2. TIME
2. Pressure Indicating Systems	10
a. Without references, select statements pertaining to the operation of typical pressure indicating systems. STS: 15a Meas: W (1) Direct (2) Synchro (3) Variable Reluctance	(3)
b. Without references, select statements pertaining to the application of instrument range markings. STS: 10k Meas: W	(1)
c. Given a workbook, tools, test equipment, and trainers, perform an inspection and operational check of pressure indicating systems with an accuracy of 100% correct workbook responses. STS: 3e, 15b, 15e Meas: P	(1)
d. Given a workbook, test equipment, and trainers, troubleshoot pressure indicating systems with an accuracy of 100% correct workbook responses. STS: 3e, 15c, 15e Meas: P	(3)
e. Given a workbook, test equipment, and trainers, bench check components of pressure indicating systems with an accuracy of 100% correct workbook responses. STS: 3e, 15d, 15e Meas: P	(2)

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SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	202	31 October 1978	25

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-202 (203), Pressure Indicating Systems
3ABR32531-WB-202 (203), Pressure Indicating Systems
3ABR32531-HO- 200

Audio Visual Aids
Transparencies, Pressure Indicating Systems

Training Equipment
Gage, Direct Reading Pressure (2)
Deadweight Tester (2)
Toolkit (12)
Trainer, Engine Instrument (2)
Trainer, Variable Reluctance (2)
Synchro Field Tester (2)
Multimeter (2)

Training Methods
Lecture/Discussion (4 hrs)
Performance (6 hrs)

Multiple Instructor Requirements
Equipment, Supervision (2)

Instructional Guidance
Using transparencies, discuss pressure indicating systems. Provide students with all required instructional material. Provide assistance to the student in the laboratory stations as required, insure safety standards are maintained, and certify attainment of criterion objectives.

MIR: Two instructors can monitor 6 students.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Engine Instruments

1. COURSE CONTENT	2. TIME
3. Tachometer Systems	7

a. Without references, select statements pertaining to the operation of tachometer systems. STS: 14a Meas: W

b. Given a workbook, test equipment and trainer, perform an inspection and operational check of a tachometer system with an accuracy of 100% correct workbook responses. STS: 3e, 14b, 14e Meas: P

c. Given a workbook, test equipment, and trainer, troubleshoot a tachometer system with an accuracy of 100% correct workbook responses. STS: 3e, 14c, 14e Meas: P

d. Given a workbook, test equipment, and trainer, bench check components of a tachometer system with an accuracy of 100% correct workbook responses. STS: 3e, 14d, 14e Meas: P

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	203	31 October 1978	27

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-HO- 200
3ABR32531-PT-203, Tachometer Systems
3ABR32531-WB-203 (202), Tachometer Systems

Audio Visual Aids
Transparencies, Tachometer Systems

Training Equipment
Trainer, Engine Instruments (2)
Trainer, Tachometer Indicator (2)
Trainer, Tachometer Generator (2)
Tachometer Tester (2)
Multimeter (2)

Training Methods
Lecture/Discussion (3 hrs)
Performance (4 hrs)

Multiple Instructor Requirements
Supervision, Equipment (2).

Instructional Guidance
Using transparencies, discuss tachometer systems. Provide students with all required instructional materials. Provide assistance to students in the laboratory stations as required. Insure safety standards are maintained, and certify attainment of criterion objectives.

MIR: One instructor can monitor 5 students during the 4-hour laboratory.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Engine Instruments

1. COURSE CONTENT	2. TIME
4. Temperature Indicating Systems	10
a. Without references, select statements pertaining to the operation of typical temperature indicating systems. STS: 13a Meas: W (1) Resistance Thermometer (2) Thermocouple Thermometer	(5)
b. Given a workbook, tools, test equipment, and trainers, perform an inspection and operational check of temperature indicating systems with an accuracy of 100% correct workbook responses. STS: 3e, 13b, 13e Meas: P	(1)
c. Given a workbook, test equipment, and trainers, troubleshoot temperature indicating systems with an accuracy of 100% correct workbook responses. STS: 3e, 13c, 13e Meas: P	(2)
d. Given a workbook, test equipment, and trainers, bench check components of a temperature indicating system with an accuracy of 100% correct workbook responses. STS: 3e, 13d, 13e Meas: P	(2)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	204	31 October 1978	29

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-204, Temperature Indicating Systems
3ABR32531-WB-204, Temperature Indicating Systems
3ABR32531-HO- 200

Audio Visual Aids
Transparencies, Temperature Indicating Systems

Training Equipment
Trainer, Resistance Thermometer Type Temperature Indicating System (2)
Trainer, Exhaust Gas Temperature Indicating System (2)
Jetcal Tester (2)
Electrical Thermometer Tester (2)
Wheatstone Bridge (2)
Multimeter (2)
Liquid-in-Glass Thermometer (1)

Training Methods
Lecture/Discussion (5 hrs)
Performance (5 hrs)

Multiple Instructor Requirements
Safety, Supervision, Equipment (2)

Instructional Guidance
Using transparencies discuss temperature indicating systems. Provide students with all required instructional materials. Provide assistance to the student in the laboratory as required. Insure safety standards are maintained, and certify attainment of criterion objectives.

MIR: One instructor can monitor 6 students during the 5-hour laboratory.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Avionics Instrument Systems Specialist

BLOCK TITLE
Engine Instruments

1. COURSE CONTENT	2. TIME
5. Fuel Flow Indicating Systems	7

5. Fuel Flow Indicating Systems

a. Without references, select statements pertaining to the operation of a fuel flow indicating system. STS: 16a Meas: W

b. Given a workbook and trainer, perform an inspection and operational check of a fuel flow indicating system with an accuracy of 100% correct workbook responses. STS: 3e, 16b Meas: P

c. Given a workbook, test equipment, and trainer, troubleshoot the fuel flow indicating system with an accuracy of 75% correct workbook responses. STS: 3e, 16c, 16e Meas: P

d. Given a workbook, test equipment, and trainer, bench check components of a fuel flow indicating system with an accuracy of 100% correct workbook responses. STS: 3e, 16d, 16e Meas: P

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	205	31 October 1978	31

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-205, Fuel Flow Indicating System
3ABR32531-WB-205, Fuel Flow Indicating System
3ABR32531-HO- 200

Audio Visual Aids
Transparencies, Fuel Flow Indicating Systems

Training Equipment
Trainer, Fuel Flow Rate Indicating System (2)
Trainer, Fuel Flow Transmitter (2)
Multimeter (2)
Synchro Field Tester (2)

Training Methods
Lecture/Discussion (4 hrs)
Performance (3 hrs)

Multiple Instructor Requirements
Safety, Equipment, Supervision (2)

Instructional Guidance
Using transparencies, discuss the fuel flow indicating system. Provide students with all required instructional materials. Provide assistance to students in the laboratory stations as required. Insure safety standards are maintained, and certify attainment of criterion objectives.

MIR: One instructor can monitor 3 trainers during the laboratory.

25

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE

Engine Instruments

1. COURSE CONTENT	2. TIME
6. Engine Pressure Ratio Indicating Systems	7
a. Without references, select statements pertaining to the operation of typical engine pressure ratio systems. STS: 15a Meas: W	
b. Given a workbook, tools, test equipment, and trainer, perform an inspection and operational check of an engine pressure ratio system with an accuracy of 100% correct workbook responses. STS: 3e, 15b, 15e Meas: P	
c. Given a workbook, test equipment, and trainer, troubleshoot the engine pressure ratio system with an accuracy of 100% correct workbook responses. STS: 3e, 15c, 15e Meas: P	
d. Given a workbook, test equipment, and trainer, bench check components of an engine pressure ratio system with an accuracy of 100% correct workbook responses. STS: 3e, 15d, 15e Meas: P	

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	206	31 October 1978	33

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

26

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-206, Engine Pressure Ratio System
3ABR32531-WB-206, Engine Pressure Ratio System
3ABR32531-HO-200

Audio Visual Aids
Transparencies, Engine Pressure Ratio

Training Equipment
Trainer, Engine Instruments (2)
Pneumatic Tester (2)
Multimeter (2)
Toolkit (12)

Training Methods
Lecture/Discussion (4 hrs)
Performance (3 hrs)

Multiple Instructor Requirements
Safety, Equipment, Supervision (2)

Instructional Guidance
Using transparencies, discuss ehe engine pressure ratio system. Provide student with all required instructional materials. Provide assistance to students in the laboratory stations as required. Insure safety standards are maintained, and certify attainment of criterion objectives.

MIR: One instructor can monitor 6 students in the 3 hours of laboratory time.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE

Engine Instruments

1. COURSE CONTENT	2. TIME
7. Resistance-Type Liquid Quantity System	5

a. Without references, select statements pertaining to the operation of the resistance-type liquid quantity indicating system. STS: 18a Meas: W

b. Given a workbook and trainer, perform an inspection and operational check of the resistance-type liquid quantity system with an accuracy of 100% correct workbook responses. STS: 3e, 18b Meas: P

c. Given a workbook, test equipment, and trainer, troubleshoot the resistance-type liquid quantity indicating system with an accuracy of 100% correct workbook responses. STS: 3e, 18c, 18f Meas: P

d. Given a workbook, test equipment, and trainer, bench check components of the resistance-type liquid quantity indicating system with an accuracy of 100% correct workbook responses. STS: 3e, 18d, 18f Meas: P

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	207	31 October 1978	35

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-207, Resistance-Type Liquid Quantity System
3ABR32531-WB-207, Resistance-Type Liquid Quantity System
3ABR32531-HO- 200

Audio Visual Aids
Transparencies, Liquid Quantity, Resistance Type

Training Equipment
Trainer, Resistance-Type Liquid Quantity Indicating System (2)
Wheatstone Bridge (2)
Multimeter (2)

Training Methods
Lecture/Discussion (2.5 hrs)
Performance (2.5 hrs)

Multiple Instructor Requirements
Equipment, Supervision (2)

Instructional Guidance
Discuss resistance type liquid quantity systems, using transparencies. Provide students with all required instructional materials. Provide assistance to the student in the laboratory stations as required. Insure safety standards are maintained, and certify attainment of the criterion objectives.

MIR: One instructor can monitor 6 students during the 2.5 hours of laboratory.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Engine Instruments

1. COURSE CONTENT	2. TIME
8. Capacitance Liquid Quantity System	13
a. Without reference, select statements pertaining to the operation of the capacitance liquid quantity indicating system. STS: 18a Meas: W	(6)
b. Given a workbook and trainer, perform an inspection and operational check of the capacitance liquid quantity indicating system with an accuracy of 100% correct workbook responses. STS: 3e, 18b Meas: P	(2)
c. Given a workbook, test equipment, and trainer, troubleshoot the capacitance liquid quantity indicating system with an accuracy of 75% correct workbook responses. STS: 3e, 18c, 18f Meas: P	(2.5)
d. Given a workbook, test equipment, and trainer, bench components and calibrate the capacitance liquid quantity indicating system with an accuracy of 100% correct workbook responses. STS: 3e, 18d, 18e, 18f Meas: P	(2.5)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	208	31 October 1978	37

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-208, F-111 Capacitance Indicating System
3ABR32531-WB-208, F-111 Capacitance Indicating System
3ABR32531-HO-208, F-111 Capacitance Indicating System Wiring Diagram
3ABR32531-HO- 200

Audio Visual Aids
Transparencies, Capacitance Liquid Quantity

Training Equipment
Trainer, Capacitance Type Liquid Quantity Indicating System (3)
Test Set, Capacitance Type Liquid Quantity System (3)
Multimeter (3)

Training Methods
Lecture/Discussion (6 hrs)
Performance (7 hrs)

Multiple Instructor Requirements
Equipment, Supervision (2)

Instructional Guidance
Using transparencies and handouts, discuss capacitance liquid quantity. Provide students with all required instructional materials. Provide assistance to the student in the laboratory stations as required. Insure safety standards are maintained and certify attainment of criterion objectives.

MIR: One instructor can monitor two trainers.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE

Engine Instruments

1. COURSE CONTENT	2. TIME
9. Vertical Scale Engine Instrument Systems	10
a. Without references, select statements pertaining to the operation of the typical vertical scale engine instruments. STS: 17a Meas: W (1) Tachometers (2) Exhaust Gas Temperature (3) Engine Pressure Ratio (4) Fuel Flow	(6)
b. Given a workbook, tools, test equipment, and trainer, perform an inspection and operational check of vertical scale engine instruments with an accuracy of 100% correct workbook responses. STS: 3e, 17b, 17e Meas: P	(1)
c. Given a workbook, test equipment, and trainer, troubleshoot vertical scale engine instruments with an accuracy of 80% correct workbook responses. STS: 3e, 17c, 17e Meas: P	(1.5)
d. Given a workbook, test equipment, and trainer, bench check components of vertical scale engine instruments with an accuracy of 100% correct workbook responses. STS: 3e, 17d, 17e Meas: P	(1.5)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	II	209	31 October 1978	39

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-209, Vertical Scale Engine Instruments
3ABR32531-WB-209, Vertical Scale Engine Instruments
3ABR32531-HO- 200

Audio Visual Aids
Transparencies, Vertical Scale Engine Instruments

Training Equipment
Trainer, Vertical Scale Engine Indicating System (2)
Engine Instrumentation System Test Set (2)
Test Set, Converter (2)
Jetcal Tester (2)
Pneumatic Tester (2)
Multimeter (2)
Converter (2)
Toolkit (2)

Training Methods
Lecture/Discussion (6 hrs)
Performance (4 hrs)

Multiple Instructor Requirements
Safety, Supervision, Equipment (2)

Instructional Guidance
Provide students with all required instructional materials. Provide assistance to the student in the laboratory stations as required. Insure safety standards are maintained, and certify attainment of criterion objectives. After all objectives have been met, collect all reusable student materials.

MIR: One instructor can monitor 2 trainers during the 4 hours of laboratory.

10. Military Training	4
a. Physical Conditioning	(4)
11. Written Test and Critique	2

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Flight Instruments

1. COURSE CONTENT	2. TIME
NOTE: The standard of performance for all knowledge criterion objectives is the passing score on the written test.	
1. Pitot-Static Systems and Instruments	18
a. Without reference, select statements pertaining to the operation of the pitot-static system and instruments. STS: 19a Meas: W	(6)
b. Without references, select statements concerning the use of pitot-static system and instruments test equipment. STS: 19e Meas: W	(2)
c. Given a workbook, test equipment and trainer, perform an inspection and operational check of the pitot-static system with a minimum of 100% accurate workbook responses. STS: 3e, 19b, 19e Meas: P	(1)
d. Given a workbook, handout, test equipment and trainer, troubleshoot components of the pitot-static system with a minimum of 75% accurate workbook responses. STS: 8d. 3e, 19c, 19e Meas: P	(1)
e. Given a workbook, test equipment, tools and trainer, bench check components of the pitot-static system with a minimum accurate workbook responses of 80%. STS: 3e, 19d, 19e Meas: P	(8)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	III	301	31 October 1978	41

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-301, Pitot-Static System
3ABR32531-WB-301, Operational Check, Inspection, Troubleshooting and Bench Check of the Pitot-Static System
3ABR32531-HO-301, Pitot-Static System Schematic

Audio Visual Aids
Training Film AVA 550, Altimeter Setting Adjustment
Flip Charts, Pitot Static System

Training Equipment
Barometer, Mercurial A-1 (2)
Vacuum Chamber (2)
Timer (2)
Manometer, Vertical (2)
Test Set, Pitot-Static System, Field MB-1 (2)
Pitot-Static System (2)
Screwdriver (2)
Applicable Indicators (2)

Training Methods
Discussion (8 hrs)
Performance (10 hrs)
hrs)

Multiple Instructor Requirements
Equipment, Supervision (2)

Instructional Guidance
Insure student understanding of pitot and static pressure differences and sensing elements used to detect these pressures; also, the wide variety of pitot-static systems depending on the type of aircraft. Enforce instruction concerning various pitot-static instruments and the pressures they use, as opposed to the pressures they measure. Also stress the relationship of mach to the speed of sound with changing altitudes. In the lab, make sure the students understand the purpose and use of the altimeter setting and conversion charts. Check all connections of the mercurial manometers and insure water shut-off remains closed during high airspeed and altitude checks.

MIR: One instructor can monitor 6 students in laboratory performance.

35

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Flight Instruments

1. COURSE CONTENT	2. TIME
2. Automatic Altitude Reporting System (AIMS)	18
a. Without references, select statements pertaining to the operation of the automatic altitude reporting system and instruments. STS: 29a Meas: W	(4)
b. Without reference, select statements pertaining to the use of AIMS test equipment. STS: 29e Meas: W	(2)
c. Without references, select statements pertaining to troubleshooting the automatic altitude reporting system. STS: 29c Meas: W	(2)
d. Given a workbook, test equipment and trainer, perform an inspection and operational check of an automatic altitude reporting system with a minimum of 100% accurate workbook responses. STS: 3e, 29b, 29e Meas: P	(2)
e. Given a workbook, test equipment and trainer, bench check components of an automatic altitude reporting system with a minimum of 80% accurate workbook responses. STS: 3e, 29d, 29e Meas: P	(8)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	III	302	31 October 1978	43

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-302, Pressure Temperature Test Set, TTU-205C/E
3ABR32531-PT-302A, Automatic Altitude Reporting Equipment (AIMS)
3ABR32531-WB-302, Leak Check of the TTU-205C/E PTTS
3ABR32531-WB-302A, Inspection, Operational and Bench Check (AIMS)
3ABR32531-HO-302 (303), Pitot Pressure and Pitot-Static Control Panel and Operating Instructions

Audio Visual Aids
Flip Charts, Automatic Altitude Reporting Equipment

Training Equipment
Test Set, Pressure Temperature, TTU-205C/E (2)
Altimeter, Servoed, AAU-19/A (2)
Computer, Transponder, Altitude, Altitude Coding, CPU-46/A-3 (2)
Pitot Pressure and Pitot-Static Control Panel (2)
Test Set, Automatic Altitude Reporting, Encoders and Altimeters, TTU-229/E (2)

Training Methods
Discussion (8 hrs)
Performance (10 hrs)

Multiple Instructor Requirements
Equipment, Supervision (2) •

Instructional Guidance
Insure students understanding of the servoed altimeter operations in either standby (pneumatic) or electrical reset mode and equipment furnishing inputs for these modes of operation. Provide assistance in labs as required, insure safety standards are maintained at all times and attainment of criterion objectives.

MIR: One instructor can monitor 4 students in laboratory performance.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Flight Instruments

1. COURSE CONTENT	2. TIME
3. Accelerometers	2
a. Without references, select statements pertaining to operation of accelerometers. STS: 33a Meas: W	
b. Given a worksheet and accelerometer, perform an inspection and operational check of a vertical accelerometer with a minimum of 100% accuracy in worksheet responses. STS: 33b Meas: P	

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	III	303	31 October 1978	45

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-303 (402A), Operation of Accelerometers
3ABR32531-WS-303 (402), Inspection and Operational Check of Accelerometer

Audio Visual Aids
Flip Charts, Accelerometers

Training Equipment
Accelerometer (1)

Training Methods
Discussion (1.5 hrs)
Performance (.5 hrs)

Instructional Guidance
Stress importance that students remember to release locking knob on installation of new accelerometers. Provide assistance to students in lab area as required. Insure safety standards are maintained and students attain criterion objectives.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Avionics Instrument Systems Specialist

BLOCK TITLE
Flight Instruments

1. COURSE CONTENT	2. TIME
4. Flight Data Recorders	2
a. Without references,select statements pertaining to the operation of flight data recorders. STS: 30a Meas: W	
b. Without references, convert binary numbers to decimal and/or decimal to binary. STS: 30a Meas: W	

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	III	304	31 October 1978	47

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-304 (303), Operation of Flight Data Recorders

Audio Visual Aids
Flip Charts, Flight Data Recorders

Training Methods
Discussion (2 hrs)

Instructional Guidance
Insure students know the purpose of flight data recorders in relation to Aircraft Structural Integrity Program, and that recorded information is in binary numbers; therefore, it is important they understand this numbering system.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Avionics Instrument Systems Specialist

BLOCK TITLE
Flight Instruments

1. COURSE CONTENT	2. TIME
5. Air Data Computer Systems and Vertical Scale Flight Instruments	33
a. Without references, select statements pertaining to the operation of the Air Data Computer, Vertical Scale Flight Instruments and Angle of Attack Systems. STS: 25a, 26a, 27a Meas: W	(16)
(1) Air Data Computer (2) Symbols for air data terms (3) Units supplying inputs to CADC (4) Units receiving outputs from CADC (5) CADC self-test circuit (6) CADC system monitor circuits (7) Airspeed mach indicator (8) Altitude Vertical Velocity Indicator (AVVI) (9) Amplifiers (10) Indexer lights (11) True Airspeed (TAS) (12) Total temeprature indicator (13) Trace signal data from sensors to displays (tapes/counters) (14) Operational check (15) Troubleshooting	
b. Given a workbook and a trainer, perform an inspection and operational check of an Air Data System. With a minimum of 100% workbook responses. STS: 3e, 25b, 25c, 26b, 26c, 27b, 27c Meas: P	(2)
c. Given a workbook, test equipment, technical data and trainer, troubleshoot an air data computer system with a minimum of 75% accurate workbook responses. STS: 3e, 4c, 8d, 25c, 25e, 26c, 26e, 27c, 27e Meas: P	(8)
d. Given a programmed text, technical data and trainer, bench check the vertical scale flight instruments with a minimum of 80% accurate workbook responses. STS: 3c, 4c, 26d, 26e Meas: P	(4)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	III	305	31 October 1978	49

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

e. Given a workbook and test equipment, bench check components of an Air Data Computer System with a minimum of 80% accurate workbook responses. STS: 3e, 25d, 25e, 27d, 27e Meas: P (3)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

3ABR32531-PT-305 (304), Central Air Data Computer System Operation
3ABR32531-PT-305A (304A), Bench Check Vertical Scale Flight Instruments
3ABR32531-PT-305B (304B), CADC System Trainer Familiarization
3ABR32531-WB-305 (304), CADC (Inspect, Operational Check, Troubleshoot)
3ABR32531-WB-305A (304A), Bench Check of Air Data Computer
3ABR32531-HO-305 (304), Vertical Scale Flight Instruments
3ABR32531-HO-305A (304A), Glossary of Terms
TO 5F5-2-27-2, Maximum Safe Speed Airspeed Indicating System
TO 5F8-9-10-2, Altitude Vertical Speed Indication System
TO 1F-111(B)A-06, Aircraft Maintenance Work Unit Code Manual
AFTO Form 349, Maintenance Data Collection Record

Audio Visual Aids

Training Film AVA 522A, Vertical Scale Instruments
Training Film AVA 522B, Altitude Vertical Velocity Indicator
Flip Charts, Air Data Computer Systems and Vertical Scale Flight Instruments

Training Equipment

Trainer Central Air Data System (2)
Test Set Pressure Temperature, TTU205C/E (2)
Pitot Pressure and Pitot-Static Control Panel (2)
Multimeter (2)
Test Bench Set CADC System AN/ASM-201B (2)
Test Set Indicator Altitude, Vertical Speed (1)
Test Set Airspeed Mach Number and Safe Speed Indicator (1)
Altitude Vertical Speed Indicator (1)
Maximum Safe Speed Airspeed Indicator (1)

Training Methods

Discussion (16 hrs)
Performance (17 hrs)

Multiple Instructor Requirements

Equipment Supervision (2)

Instructional Guidance

When tracing signal data flow through the CADC system, stress similarity in methods of signal processing from CADC to the indicating tape, counter, etc. Also, relate the synchro system schematic used previously by students in Electronic Principles to the wiring diagrams of synchro systems in CADC handouts. In lab areas, insure attainment of criterion objectives by students and observe and practice all safety procedures. After all objectives have been met, collect all reusable student materials.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Integrated Flight and Navigational Instruments

1. COURSE CONTENT	2. TIME
NOTE: The standard of performance for all knowledge criterion objectives is the passing score on the written test.	
1. Flight Instruments (Gyro Type)	10
a. Without reference, select statements pertaining to the operation of gyroscopic flight instruments. STS: 20a Meas: W (1) Gyroscopic principles (2) Directional Gyro Indicator (3) Bank and Turn Indicator (4) Attitude Gyro Indicator	(8)
b. Given a workbook, test equipment and components, perform an inspection and operational check of flight instruments with a minimum of 100% accurate workbook responses. STS: 3e, 20b, 20e Meas: P	(.5)
c. Given a workbook, test equipment and components, perform bench check of representative flight instruments with a minimum of 100% accurate workbook responses. STS: 3e, 20d, 20e Meas: P	(1)
d. Given a workbook, test equipment and trainer, troubleshoot flight instruments with a minimum of 80% accurate workbook responses. STS: 3e, 20c, 20e Meas: P	(.5)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	IV	401	31 October 1978	53

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

3ABR32531-PT-401 (402), Gyroscopic Flight Instruments
3ABR32531-WB-401 (402), Inspection, Bench Check and Adjustment of the Bank and Turn Indicator

Audio Visual Aids

AVA 521 or AVA 521A and 521B, Gyroscopic Principles

Training Equipment

Gyro Demonstrator (2)
Attitude Gyro Indicator (2)
Directional Gyro Indicator (2)
Bank and Turn Indicator (3)
Rate Table (3)
Power Control Panel (3)
Multimeter (3)
Stroboscope (2)

Training Methods

Lecture/Discussion (8 hrs)
Demonstration/Performance (2 hrs)

Multiple Instructor Requirements

Safety, Equipment and Supervision (2)

Instructional Guidance

Using appropriate audio visual aids, explain Gyroscope Flight Instruments operation and maintenance. The students will perform maintenance operations on Gyroscopic Flight Instruments. In the lab insure safety standards are maintained and certify attainment of the criterion objectives.

MIR: One instructor can monitor 2 trainers.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Integrated Flight and Navigation Instruments

1. COURSE CONTENT	2. TIME
2. Direct Reading (Standby) Compass	4

a. Without references, select statements pertaining to the operation of direct reading compasses. STS: 21a Meas: W

(1) Operation

(2) Compass error and effects

(3) Compensator

(4) Swing procedures

b. Given a workbook and compass trainer, perform an inspection and operational check with a minimum 100% accurate workbook responses. STS: 21b Meas: P

c. Given a workbook, site compass and compass trainer, perform a swing and make compensation adjustments with a minimum 100% accurate workbook responses. STS: 21c Meas: P

d. Given a workbook, site compass and compass trainer, perform a residual swing and accomplish the pilot's correction card with a minimum 80% accurate workbook responses. STS: 21d Meas: P

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	IV	402	31 October 1978	55

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-402 (401), Operation of Magnetic (Standby) Compass
3ABR32531-WB-402 (401), Inspect, Swing and Complete Pilot's Card: Magnetic (Standby) Compass

Audio Visual Aids
Transparencies, Standby Compass

Training Equipment
Compass, Magnetic Type B-16 or B-21 (2)
Direct Reading Compass Trainer (2)
Non-Magnetic Screwdriver (2)

Training Methods
Lecture/Discussion (2 hrs)
Demonstration/Performance (2 hrs)

Instructional Guidance
Explain the operation, maintenance and swing procedures of the direct reading compass. Insure safety standards are maintained and certify achievement of criterion objectives.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Integrated Flight and Navigational Instruments

1. COURSE CONTENT	2. TIME
3. Attitude Heading Reference and Gyro Stabilized Magnetic Compass Systeme	35
a. Without references, select statements pertaining to the operation of the attitude heading reference and gyro stabilized magnetic compass systems. STS: 22a, 24a Meas: W (1) General discription (2) Attitude system (3) Compass system	(19)
b. Given a workbook and trainer, perform an inspection and , operational check of attitude reference and compass systems with a minimum of 100% accurate workbook responses. STS: 3e, 22b, 24b Meas: P	(4)
c. Given a workbook, test equipment and trainer, troubleshoot the attitude reference and compass system with a minimum of 80% workbook responses. STS: 3e, 22c, 22e, 24c, 24e Meas: P	(12)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	IV	403	31 October 1978	57

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

3ABR32531-PT-403, Attitude Heading Reference and Gyro Stabilized Magnetic Compass Systems
3ABR32531-HO-403, Attitude Heading Reference and Gyro Stabilized Magnetic Compass Systems
3ABR32531-HO-403A, Schematic Diagrams
3ABR32531-WB-403, Attitude Heading Reference and Gyro Stabilized Magnetic Compass Systems

Audio Visual Aids

Transparencies, Attitude Heading Reference and Gyro Stabilized Magnetic Compass Systems

Training Equipment

Trainer, Auxiliary Flight Reference System (2)
Trainer, ADI (2) Exploded View
Multimeter (2)
Test Set, Line Maintenance (2)

Training Methods

Lecture/Discussion (20 hrs)
Demonstration/Performance (16 hrs)

Multiple Instructor Requirements

Safety, Equipment, Supervision (2)

Instructional Guidance

Using appropriate diagrams, explain the operation and maintenance of attitude heading reference and gyro stabilized magnetic compass systems. The students will perform maintenance operations on the attitude reference and compass system. In the lab insure safety standards are maintained and certify achievement of the criterion objectives.

MIR: One instructor can monitor 2 trainers.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Integrated Flight and Navigational Instruments

1. COURSE CONTENT	2. TIME
4. MC-1 Compass Calibration	16
a. Without references, select statements pertaining to the use and operation of the MC-1 compass calibrator. STS: 22e Meas: W (1) Capabilities (2) Components (3) Area survey (4) Compass swing	(6)
b. Given a workbook, test equipment, technical data and trainer, perform a compass swing and compensation adjustments with a minimum of 80% workbook responses. STS: 3e, 4c, 22c, 22e Meas: P	(10)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	IV	404	31 October 1978	59

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-404, MC-1 Compass Calibrator
3ABR32531-PT-404A, Azimuth Dial Readings
3ABR32531-WB-404, Use of the MC-1 Compass Calibrator
AFTO Form 53, Compass Swing Data Sheet
TO 5N3-3-7-1, Magnetic Compass Calibrator Set (MC-1)

Audio Visual Aids
Transparencies, MC-1 Compass Calibrator

Training Equipment
Trainer, Auxiliary Flight Reference (4)
MC-1 Compass Calibrator Set (4)
Adapter Kit (4)

Training Methods
Lecture/Discussion (6 hrs)
Demonstration/Performance (10 hrs)

Multiple Instructor Requirements
Safety, Equipment, Supervision (2)

Instructional Guidance
Using appropriate diagrams, explain the purpose and operation of the MC-1 compass calibrator. The students will perform a compass swing in the lab. Insure safety standards are maintained and certify achievement of the criterion objectives.

MIR: One instructor can monitor 2 trainers.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Avionics Instrument Systems Specialist

BLOCK TITLE
Integrated Flight and Navigational Instruments

1. COURSE CONTENT	2. TIME
5. Electronic Test Equipment	9
a. Without reference, select statements pertaining to the operation of electronic test equipment. STS: 22e, 24e Meas: W (1) DC digital voltmeter (2) Phase angle voltmeter (3) Electronic counter (4) Oscilloscope	(3)
b. Given a workbook, test equipment, technical data and trainer, bench check various attitude and heading components with a minimum of 80% accurate workbook responses. STS: 3e, 4c, 22d, 22e, 24d, 24e Meas: P	(6)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	IV	405	31 October 1978	61

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-405 (403A), Electronic Test Equipment
3ABR32531-WB-405 (403A), Bench Check AFRS Electronic Components

Audio Visual Aids
Transparencies, Electronic Test Equipment

Training Equipment
Multimeter (3)
Test Set, Attitude Reference and Bombing Computer AN/AJM-17 (3)
Oscilloscope (3)
Voltmeter, Phase Angle (3)
Voltmeter, DC Digital (3)
Electronic Counter (3)
Amplifier Power Supply (3)
Rate of Turn Gyro Transmitter (3)
Switching Rate Gyro (3)
Dual Timer (3)

Training Methods
Lecture/Discussion (3 hrs)
Demonstration/Performance (6 hrs)

Multiple Instructor Requirements
Safety, Equipment, Supervision (2)

Instructional Guidance
Using appropriate diagrams, explain the purpose and use of electronic test equipment. In the lab insure safety standards are maintained and certify achievement of criterion objectives. The students will bench check components in the lab. After all objectives have been met, collect all reusable student materials.

MIR: One instructor can monitor 2 trainers.

6. Military Training	4
a. Physical Conditioning	(4)
7. Written Test and Critique	2

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Avionics Instrument Systems Specialist

BLOCK TITLE
Flight Director Systems

1. COURSE CONTENT	2. TIME
NOTE: The standard of performance for all knowledge criterion objectives is the passing score on the written test.	
1. Flight Director Systems	28
a. Without reference, select statements pertaining to the operation of flight director systems. STS: 23a Meas: W	(16)
b. Given a workbook and trainer, perform an inspection and operational check of the flight director systems with a minimum of 100% accurate workbook responses. STS: 3e, 23b Meas: P	(2)
c. Given a workbook, test equipment and trainer, troubleshoot the flight director system to a minimum accuracy of 80% workbook responses. STS: 3d, 23c, 23e Meas: P	(6)
d. Given a workbook, technical data, test equipment and trainer, bench check components of the flight director system with a minimum accuracy of 100% workbook responses. STS: 3e, 4c, 23d, 23e Meas: P	(4)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

POI NUMBER	BLOCK	UNIT	DATE	PAGE NO.
C3ABR32531 000	V	501	31 October 1978	63

ATC FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

COURSE CONTENT

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
3ABR32531-PT-501 (404), Flight Director Systems
3ABR32531-HO-501 (404), Flight Director Systems (Modes of Operation)
3ABR32531-HO-501A (404A), Flight Director Systems Diagrams
3ABR32531-WB-501 (404), Flight Director Systems

Audio Visual Aids
AVA 523A, Horizontal Situation Indicator
AVA 523B, Attitude Director Indicator

Training Equipment
Trainer, Auxiliary Flight Reference (2)
Multimeter (2)
Test Set, AN/ASM 159 (2)
Horizontal Situation Indicator (2)

Instructional Methods
Lecture/Discussion (16 hrs)
Demonstration/Performance (12 hrs)

Multiple Instructor Requirements
Safety, Equipment, Supervision (2)

Instructional Guidance
Using appropriate diagrams and films, explain flight director operation and maintenance. The students will perform maintenance operations on the flight director system and components. In the lab, insure safety standards are maintained and certify achievement of the criterion objectives. After all objectives have been met, collect all reusable student materials.

MIR: One instructor can monitor 2 trainers.

2.	Military Training	9
	a. Physical Conditioning	(2)
	b. End-of-Course Appointments	(7)
3.	Measurement, Written Test and Critique	2
4.	Course Critique and Graduation	1

HANDOUT
3ABR32531-HO-100

Technical Training

Avionics Instrument System Specialist

AVIONIC INSTRUMENT FUNDAMENTALS

12 July 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

56

TABLE OF CONTENTS

Title	Page
Table of Contents	2 & 3
Bibliography	4 - 6
Job Description	7 & 8
Aircraft Familiarization	9
Aircraft Axis	10
Station Numbering System	11
Aerodynamic Forces	12
Primary Flight Control Surfaces	13
Secondary and Auxiliary Flight Control Surfaces	14
Flight Control Surfaces Review	15
Aircraft Types	16
Clamp Mounting	17
Bezel Mounting	18
Bolts	19
Bolt Markings	20
Screws	21
Nuts	22
Tinnerman Mounting Nut	23
Washers	24
Fittings	25 & 26
Fasteners	27
Turnbuckles	28
Solderless Connectors	29
Electrical Connectors	30

Supersedes 3ABR32531-HO-100, 15 January 1979.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360TCHTG/TTGU-F - 200; TTVSA - 1

Title	Page
Screwdrivers	31
Wrenches	32
Sockets and Handles	33
Files	34
Pliers	35
Miscellaneous Handtools	36
Torque Wrench	37
Wire Strippers	38
Crimpers	39
Soldering Irons	40
Safetying	41
AFTO Form 349, Maintenance Data Collection Record	42
AFTO Form 781A, Maintenance Discrepancy and Work Document	43
AFTO Form 350, Repairable Processing Tag	44
Types of Technical Orders	45
Types of Time Compliance Technical Orders	46
Updating Technical Orders	47
Listing From a Technical Order	48
AFTO Form 22, Technical Order Improvement Report	49
Status Tags	50 & 51
Classification Guide	52
Bourdon Tube	53
Diaphragm	54
Aneroid	55
Bellows	56
Synchro Illustration	57

BIBLIOGRAPHY

As time permits, study the reference materials listed in this bibliography. All of the publications are available in the Chanute AFB general library or the technical library. After studying the publications listed, you will possess a much broader knowledge of the course than would otherwise be possible during normal classroom instruction.

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AFM 39-1
AFSC 32551
Semiskilled AFSC 32531

FOR TRAINING PURPOSES ONLY

AIRMAN AIR FORCE SPECIALTY

★ AVIONIC INSTRUMENT SYSTEMS SPECIALIST

1. SPECIALTY SUMMARY

Installs, inspects, repairs, operates, troubleshoots, overhauls, and modifies electronic and electro-mechanical instruments, instrument systems, components, and test equipment.

2. DUTIES AND RESPONSIBILITIES

a. *Performs preventive maintenance on electronic and electro-mechanical instruments and instrument systems:* Inspects and tests electrical, electronic/transistorized, and mechanical instrument systems and component parts such as flight and engine instrument systems; flight data recorder systems; central air data computer systems, including component parts such as computers, compensators, converters, and sensors; and gyro-stabilized attitude reference and flight director indicating systems and components, gyro/magnetic compasses, clocks, sextants, pressure, temperature, and liquid indicating systems and torque indicating systems. Turns on equipment and evaluates equipment performance using applicable test equipment. Adjusts and replaces defective units and components.

b. *Installs, repairs, troubleshoots, overhauls, and modifies electrical, electronic/transistorized, and mechanical instruments and instrument systems:* Checks components visually and by use of tools and test equipment for serviceability prior to installation. Repairs and replaces faulty wiring, electrical connectors, and pressure connections to components and systems. Troubleshoots and repairs electrical, electronic/transistorized, and mechanical instruments such as central air data computer, flight data recorder, flight director, and attitude reference systems to insure correct output for related integrated systems. Analyzes, isolates, and repairs instrument systems and component malfunctions using circuit diagrams and test equipment, such as pitot-static testers, barometers, and manometers, gyroscopic instrument testers, frequency counter, digital voltmeters, and specialized instrument systems testers and analyzers. Maintains and calibrates instrument systems test equipment as outlined in applicable technical directives. Swings and compensates gyro/magnetic compasses. Aligns, balances, calibrates, and adjusts repaired assemblies and systems. Accomplishes modification of components and systems.

c. *Maintains inspection and maintenance records:* Posts entries on applicable maintenance and inspection records. Completes maintenance data forms. Recommends methods to improve equipment performance and maintenance procedures.

d. *Supervises avionic instrument systems personnel:* Assigns maintenance and operation tasks. Observes performance to insure compliance with directives and applicable technical publications. Instructs subordinates in techniques of installation, maintenance, and repair of instruments and instrument systems. Conducts on-the-job training and demonstrates use of tools and equipment. Insures personnel adhere to appropriate procedures prescribed by USAF maintenance management directives.

3. SPECIALTY QUALIFICATIONS

a. *Knowledge:* Knowledge of theory and application of electronic and electro-mechanical principles; interpretation and application of mechanical drawings and wiring diagrams in relation to mechanical functions and electronic circuits; theory and application of servo-amplifiers; functional value of differential wiring; use, care, and interpretation of testing and measuring devices; and principles of power and motion transmission by electrical and mechanical means is *mandatory*. Possession of mandatory knowledge will be determined in accordance with AFM 35-1.

b. *Education:* Completion of high school with courses in basic electronics and mathematics is desirable.

c. *Experience:* Experience in functions such as installation, testing, inspection, repair, and

.62

overhaul of instrument systems and components is *mandatory*.

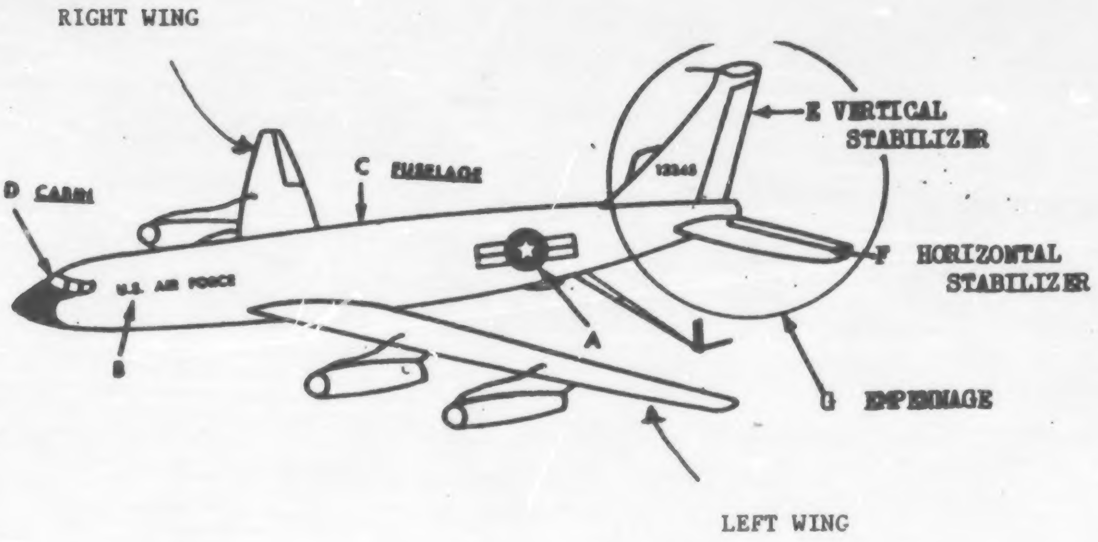
d. *Training*: Completion of a basic avionic instrument systems course is desirable.

e. *Other:*

(1) Normal color vision as defined in AFM 160–1 is *mandatory*.

(2) A minimum aptitude level of Electronic 80 is *mandatory*.

AIRCRAFT FAMILIARIZATION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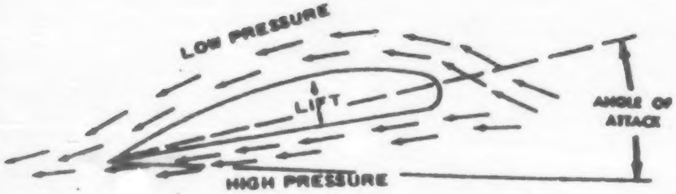
F HORIZONTAL STABILIZER
B
A
G EMPENNAGE
LEFT WING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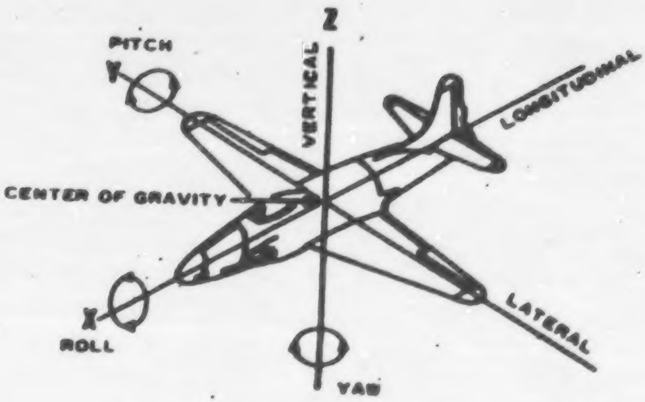
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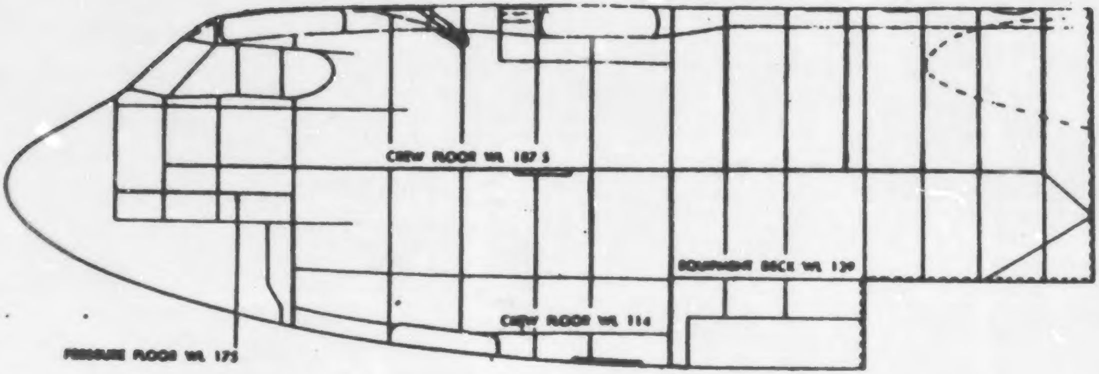
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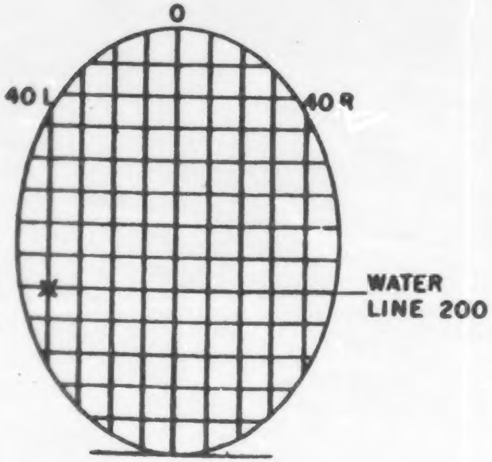
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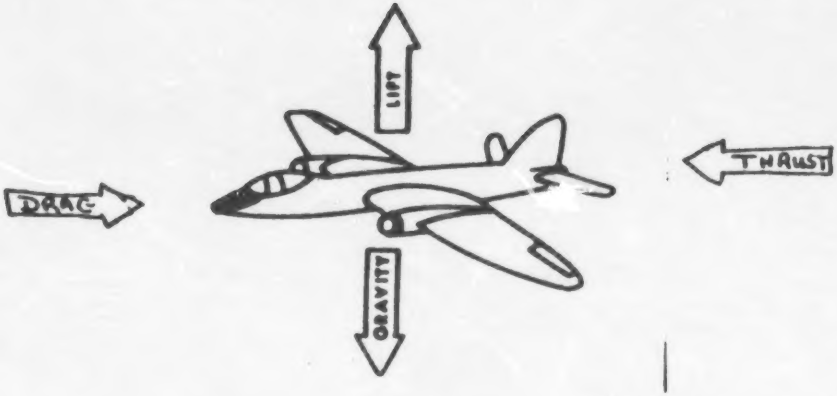
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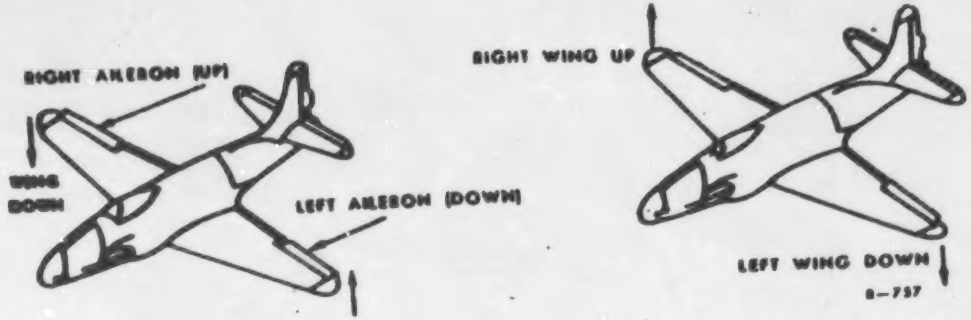
PRIMARY FLIGHT CONTROL SURFACES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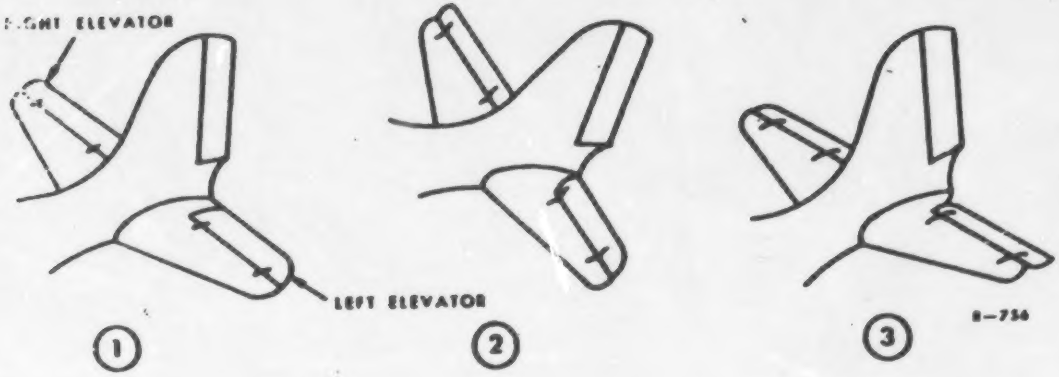
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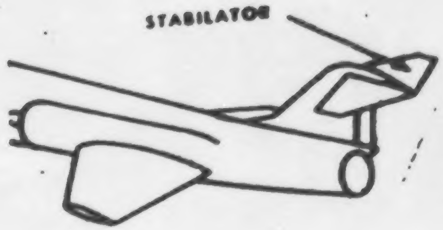
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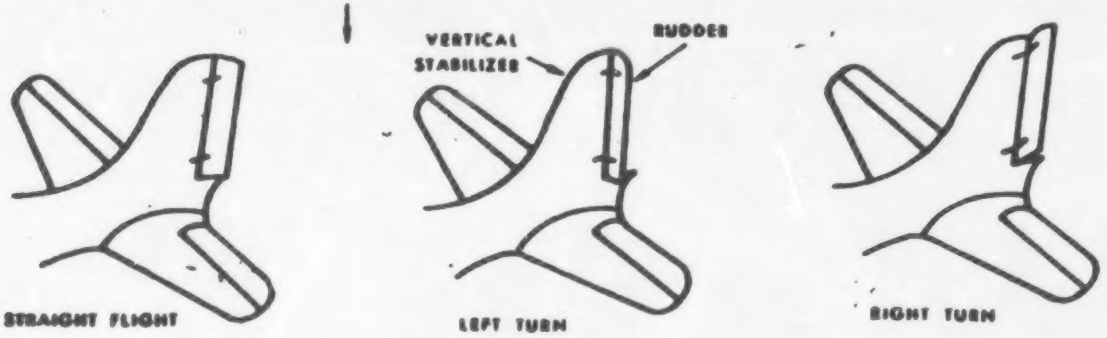
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RIGHT TURN

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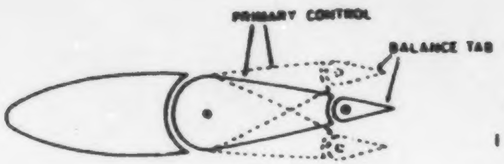
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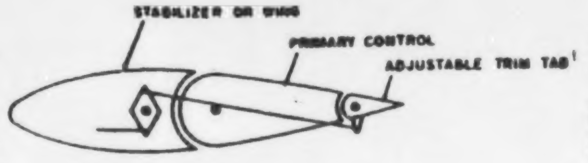
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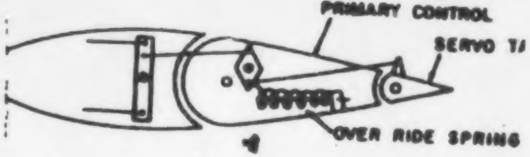
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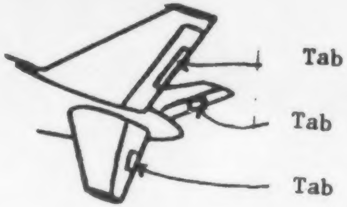
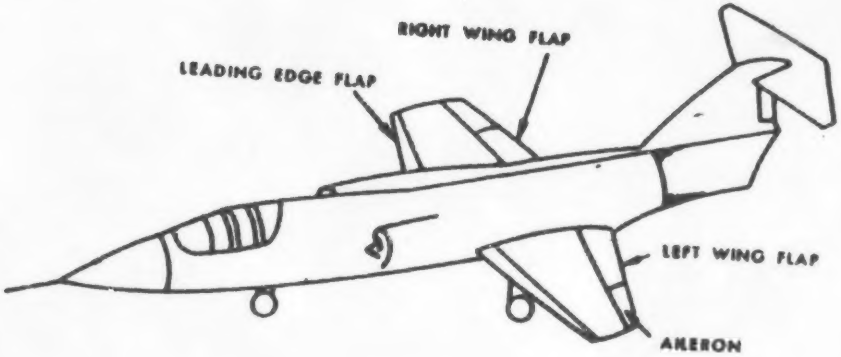


AUXILIARY FLIGHT CONTROL SURFACES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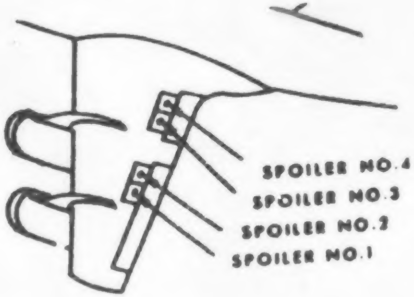
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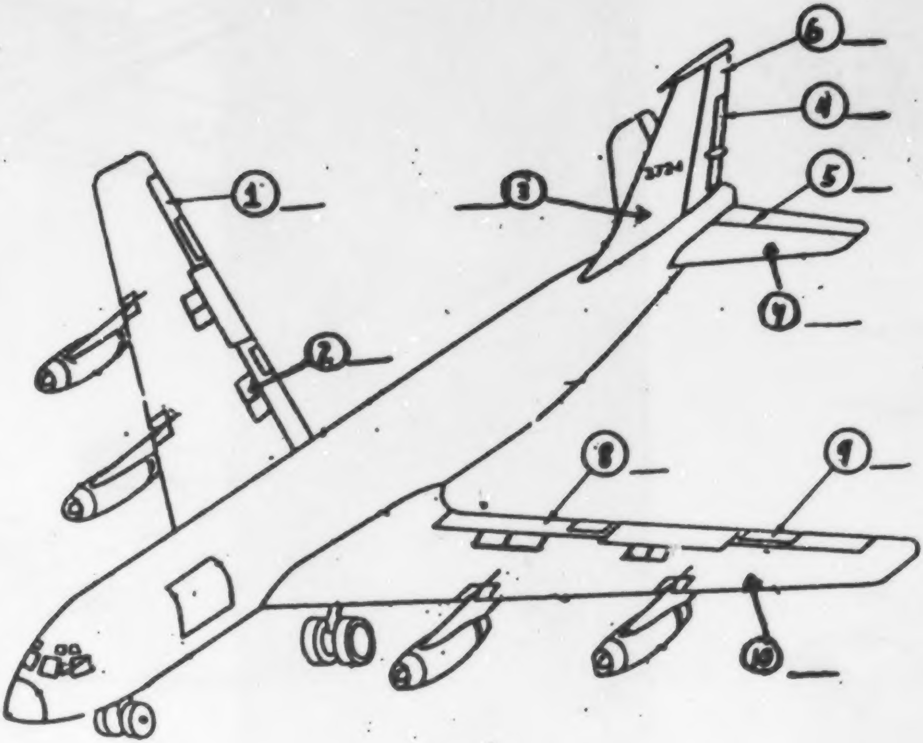
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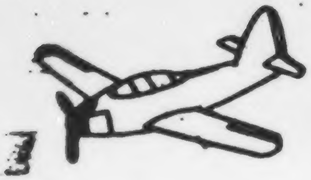
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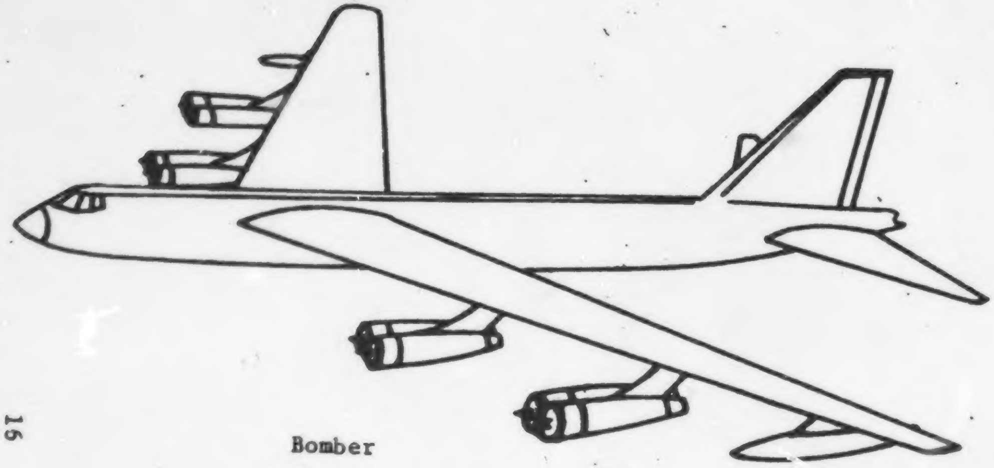
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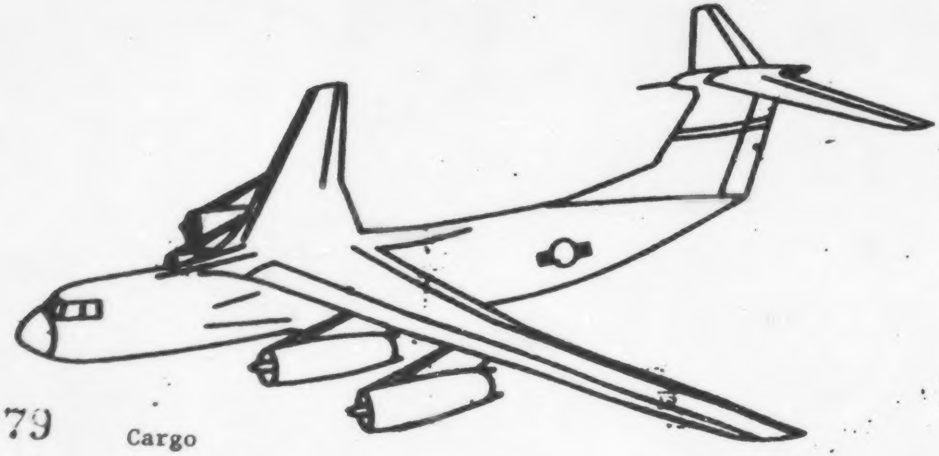
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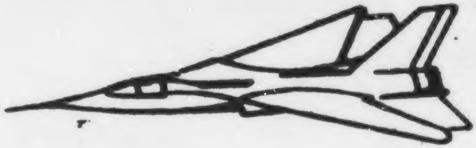
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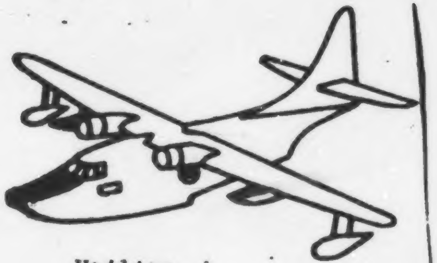
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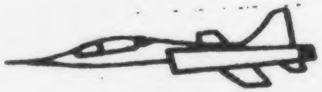
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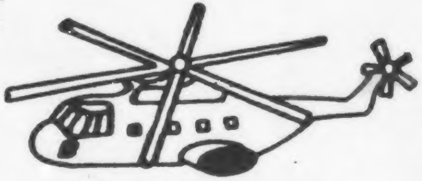

Helicopter

CLAMP MOUNTING

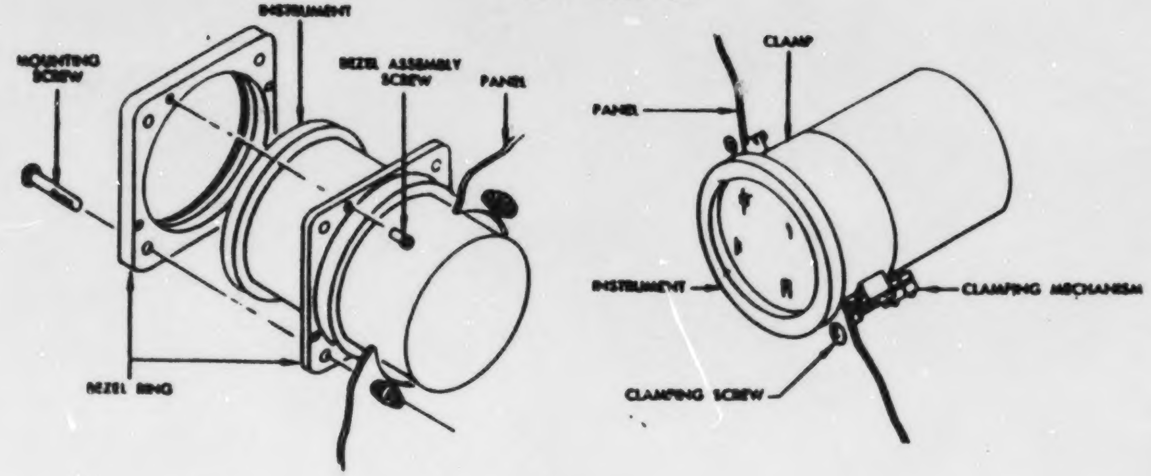
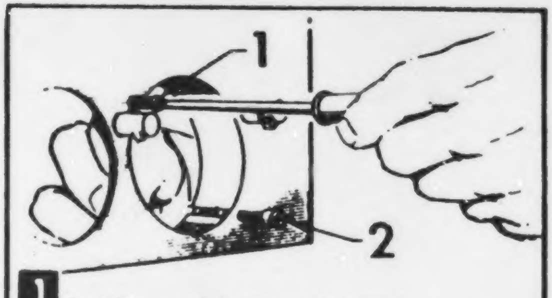

INSTRUMENT
MOUNTING SCREW
BEZEL ASSEMBLY SCREW
PANEL
BEZEL RING
CLAMP
PANEL
INSTRUMENT
CLAMPING MECHANISM
CLAMPING SCREW

Figure A

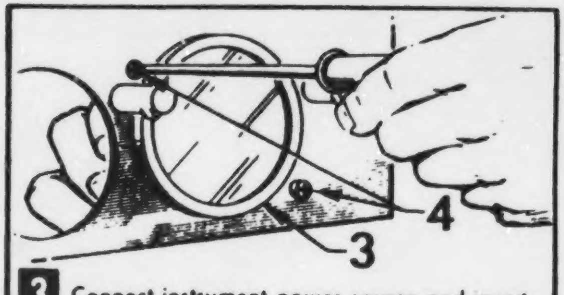
Figure B

Instrument Prepared for Clamp Mounting



1 Install upper left mounting screw.

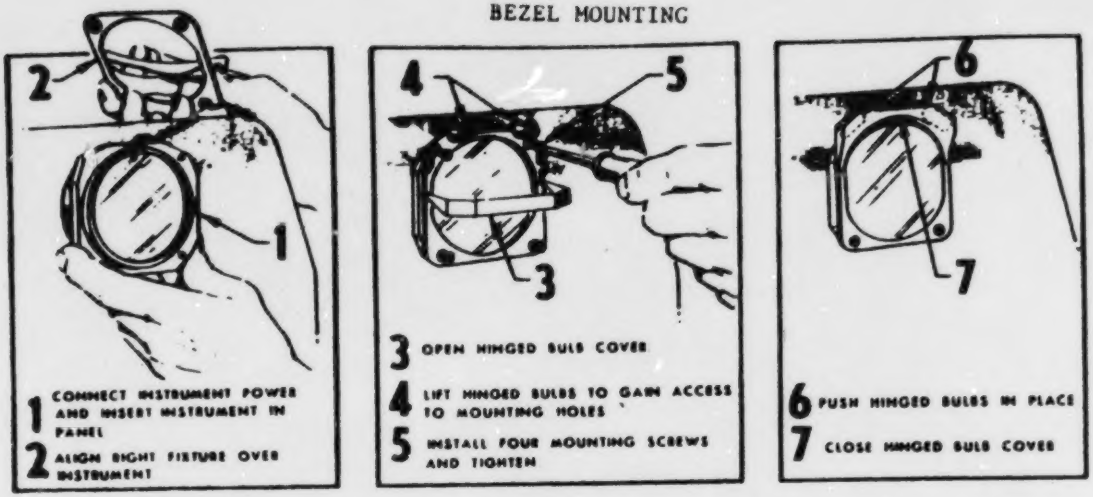
2 Install lower right clamp screw-jack screw.



3 Connect instrument power source and insert instrument in panel.

4 Tighten both screws.

BEZEL MOUNTING



1 CONNECT INSTRUMENT POWER AND INSERT INSTRUMENT IN PANEL

2 ALIGN LIGHT FIXTURE OVER INSTRUMENT

3 OPEN HINGED BULB COVER

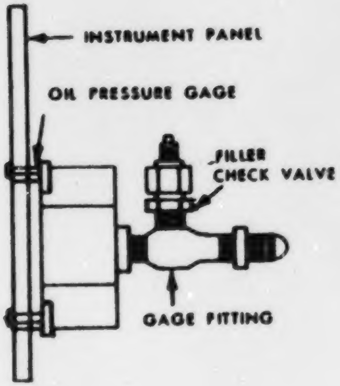
4 LIFT HINGED BULBS TO GAIN ACCESS TO MOUNTING HOLES

5 INSTALL FOUR MOUNTING SCREWS AND TIGHTEN

6 PUSH HINGED BULBS IN PLACE

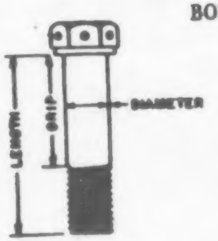
7 CLOSE HINGED BULB COVER

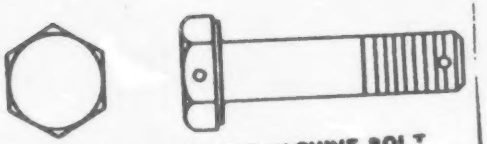
Front Bezel Mounting of Instruments


INSTRUMENT PANEL
OIL PRESSURE GAGE
FILLER
CHECK VALVE
GAGE FITTING

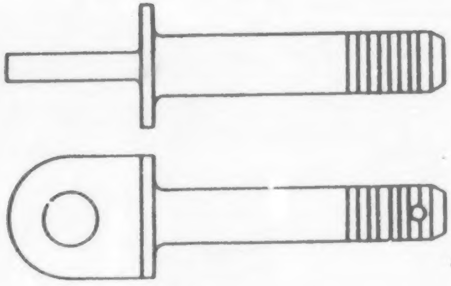
Rear Bezel Mounted Instrument

BOLTS

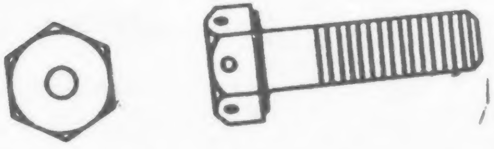

LENGTH
GRIP
DIAMETER



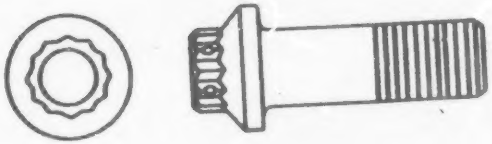
STANDARD AIRCRAFT MACHINE BOLT



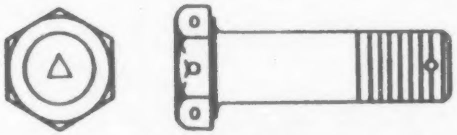
Eye Bolt



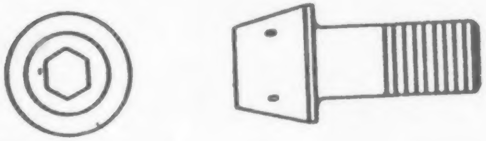
Drilled Head Bolt



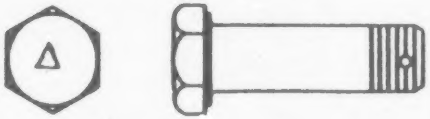
External Wrenching



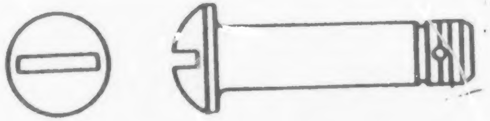
HEX HEAD, CLOSE-TOLERANCE TENSILE BOLT



Internal Wrenching

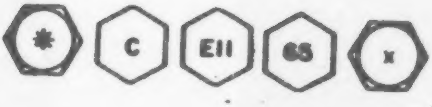


CLOSE-TOLERANCE SHEAR BOLT

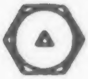


Clevis Bolt

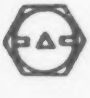
BOLT MARKINGS



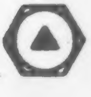
STEEL BOLT



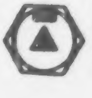
CLOSE TOLERANCE BOLT



CLOSE TOLERANCE
ALUMINUM ALLOY BOLT

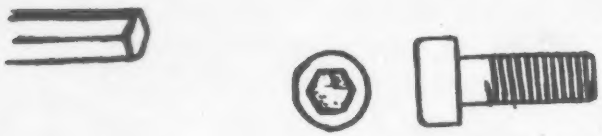


CLOSE TOLERANCE
STEEL BOLT

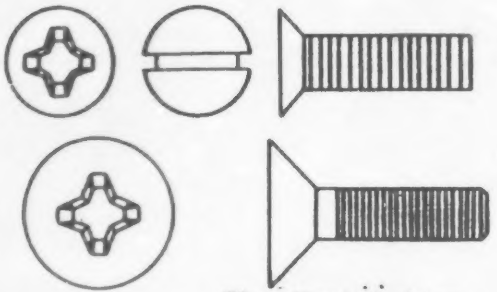


CLOSE TOLERANCE
CORROSION RESISTANT
STEEL BOLT

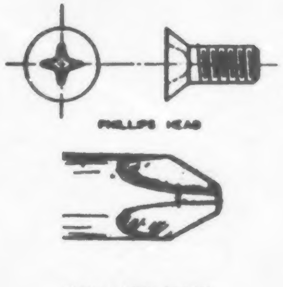
SCREWS



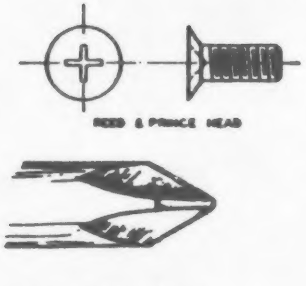
Allen Screw



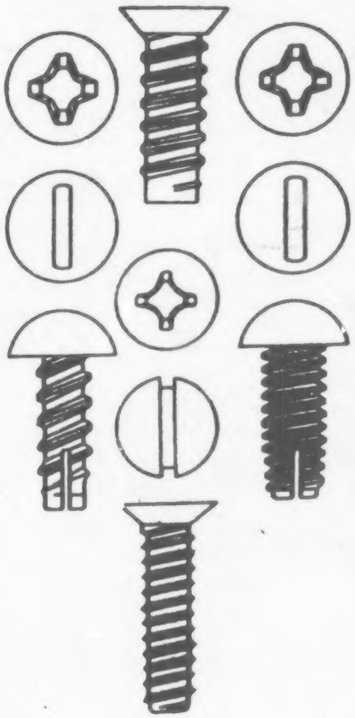
Flat Head Machine


PHILLIPS HEAD

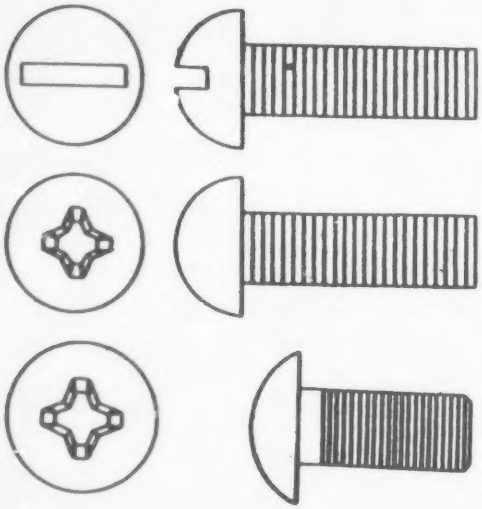
PHILLIPS TYPE


REED & PRINCE HEAD

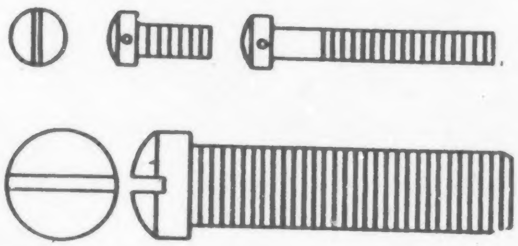
REED & PRINCE TYPE



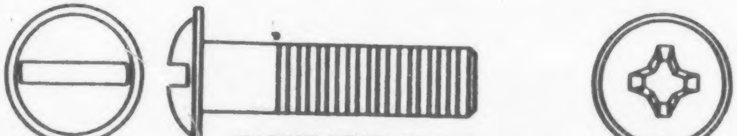
Self Tappin



General Purpose
Round Head Machine

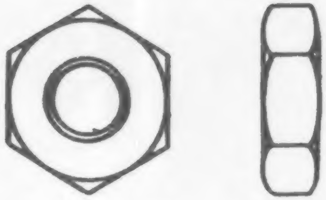


Fillister Head

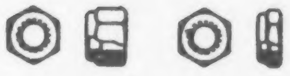


WASHER HEAD SCREW

NUTS

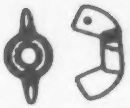


Plain Nut

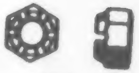


THICK THIN

SELF LOCKING NUTS



WING NUT



CASTLE NUT

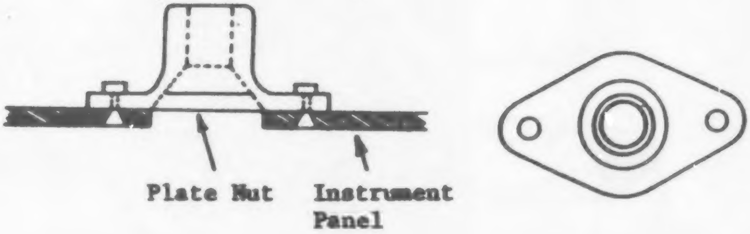
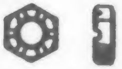
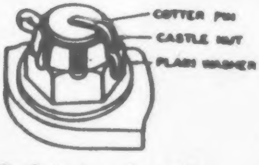


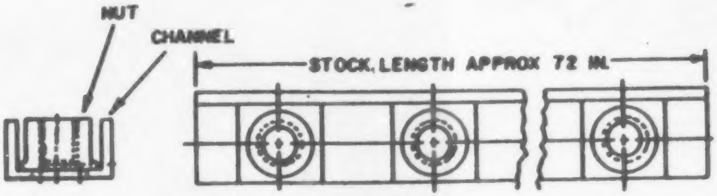
Plate Nut
Instrument Panel



SHEAR NUT

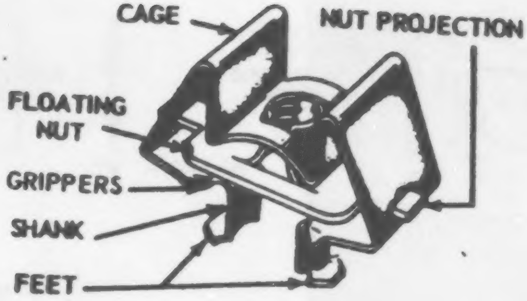

COTTER PIN
CASTLE NUT
PLAIN WASHER

Safetying by Use of Cotter Pins.

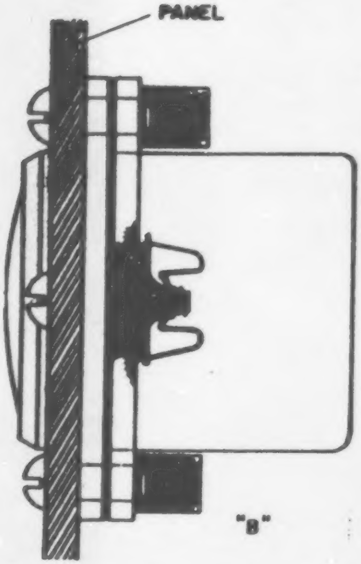

NUT
CHANNEL
STOCK LENGTH APPROX 72 IN.

Gang Channel

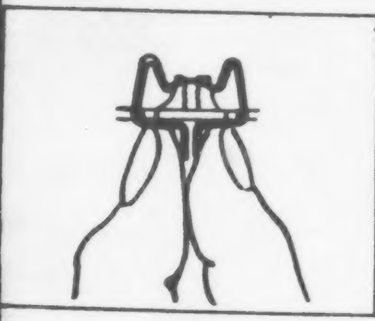
TINNERMAN MOUNTING NUT


CAGE
NUT PROJECTION
FLOATING NUT
GRIPPERS
SHANK
FEET

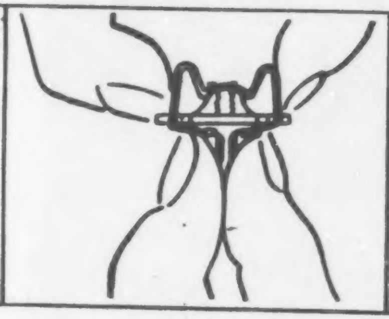
"A"



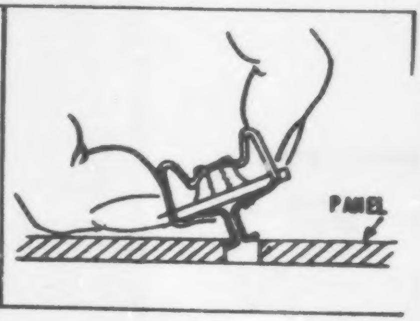
"B"



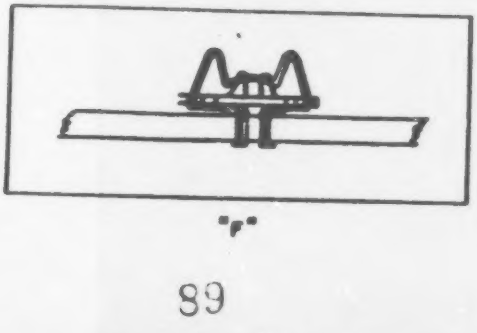
"C"



"D"

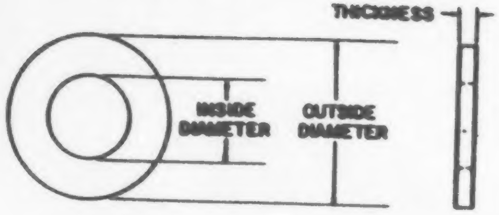


"E"

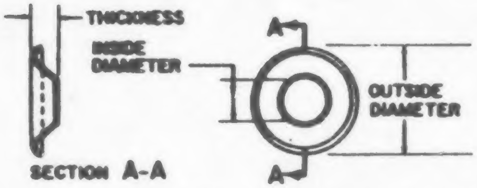


"F"

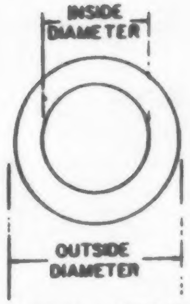
WASHERS


THICKNESS
INSIDE DIAMETER
OUTSIDE DIAMETER

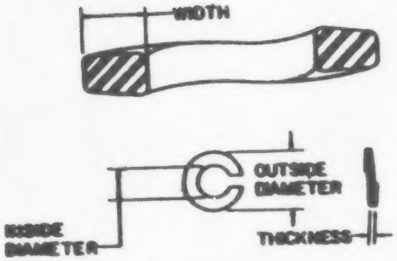
Plain Washer


THICKNESS
INSIDE DIAMETER
A
OUTSIDE DIAMETER
A
SECTION A-A

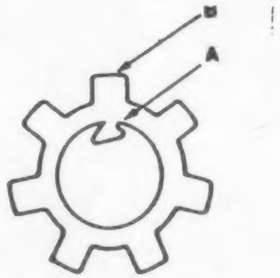
COUNTERSUNK TYPE, FINISHING WASHER


INSIDE DIAMETER
OUTSIDE DIAMETER

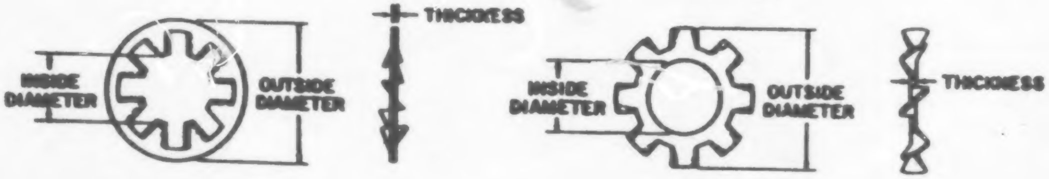
FLAT, PHENOLIC FIBER WASHER


WIDTH
OUTSIDE DIAMETER
INSIDE DIAMETER
THICKNESS

LOCKWASHER



TAB TYPE WASHER

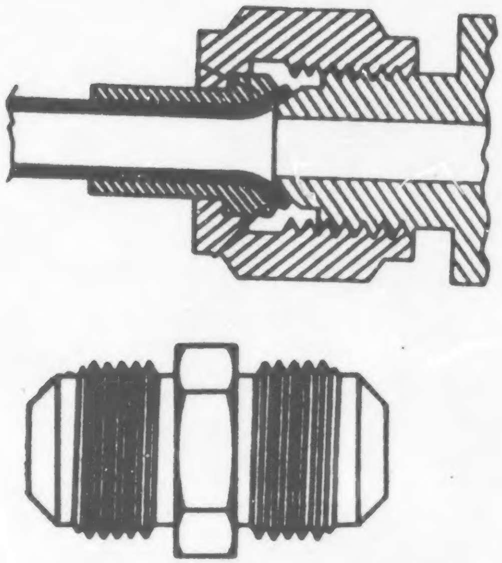

THICKNESS
INSIDE DIAMETER
OUTSIDE DIAMETER
INSIDE DIAMETER
OUTSIDE DIAMETER
THICKNESS

INTERNAL TEETH

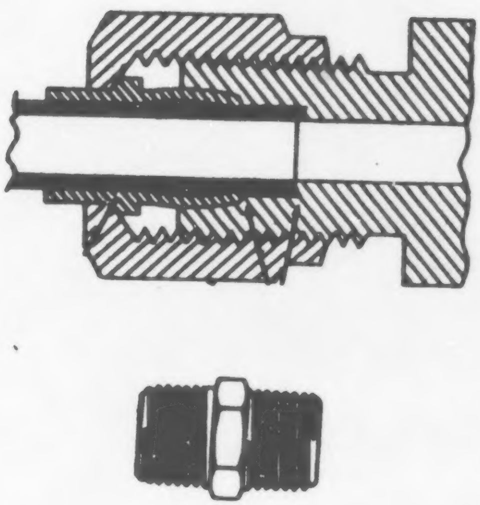
EXTERNAL TEETH

LOCKWASHER

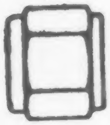
FITTINGS



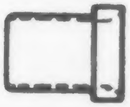
AN



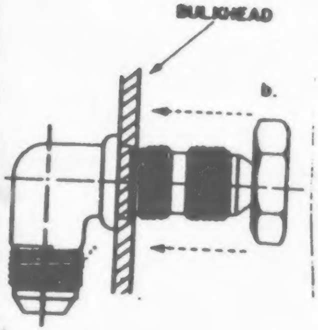
MS

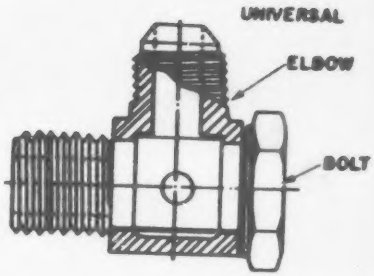


Nut:
Coupling.

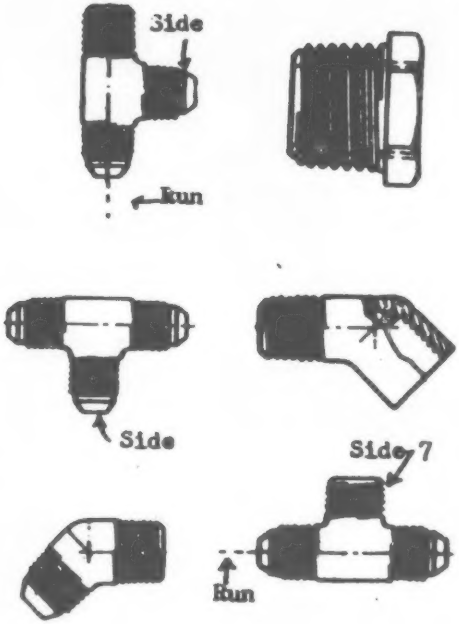


Sleeve:



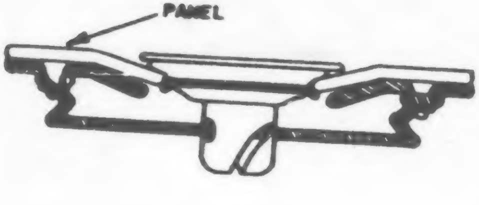

UNIVERSAL
ELBOW
BOLT

FITTINGS


Side
Run
Side
Side
Run

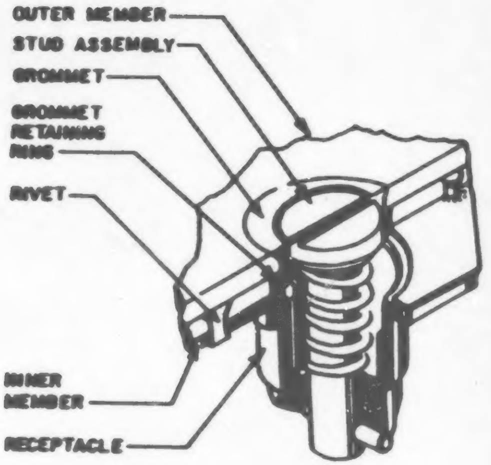
"O" Ring

FASTENERS

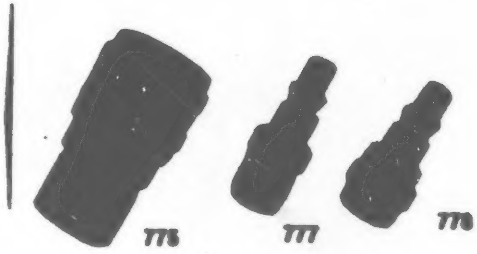


TURNLOCK FASTENER

DZUS

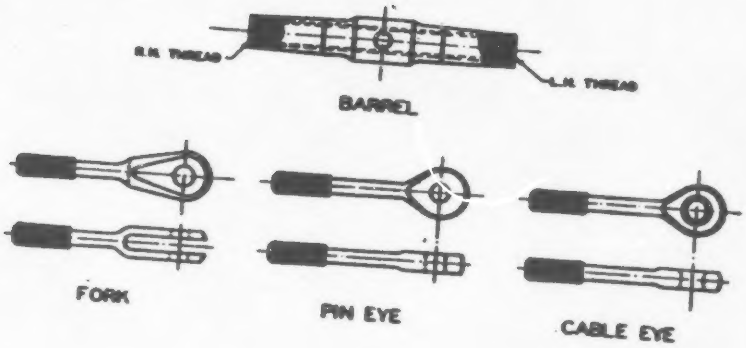

OUTER MEMBER
STUD ASSEMBLY
GROMMET
GROMMET RETAINING RING
RIVET
INNER MEMBER
RECEPTACLE

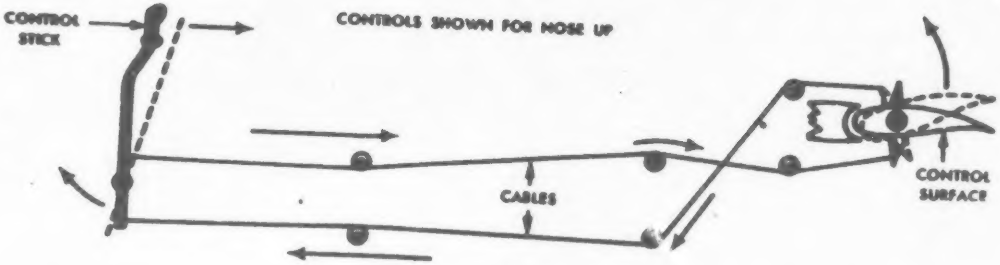
CAMLOC FASTENER



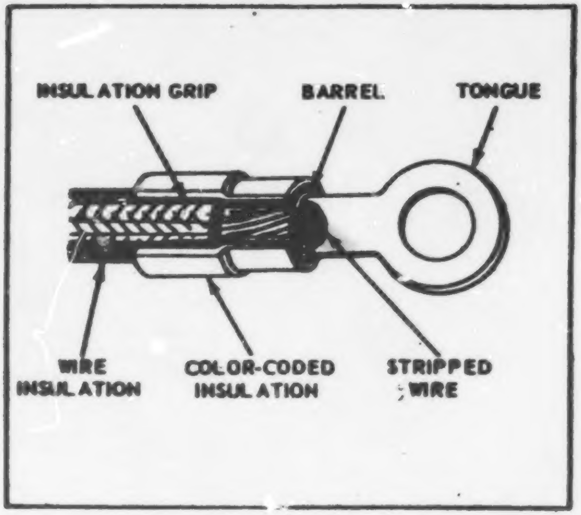
QUICK DISCONNECT

TURNBUCKLES

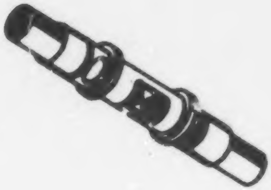

R.H. THREAD
L.H. THREAD
BARREL
FORK
PIN EYE
CABLE EYE


CONTROL STICK
CONTROLS SHOWN FOR NOSE UP
CABLES
CONTROL SURFACE

SOLDERLESS CONNECTORS

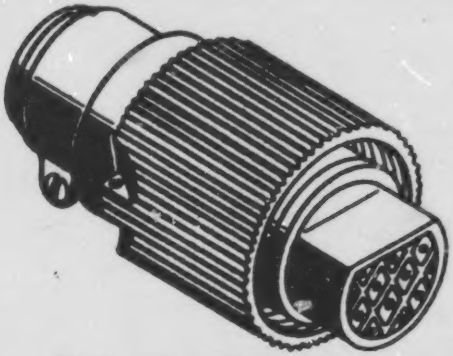

INSULATION GRIP
BARREL
TONGUE
WIRE INSULATION
COLOR-CODED INSULATION
STRIPPED WIRE

Terminal

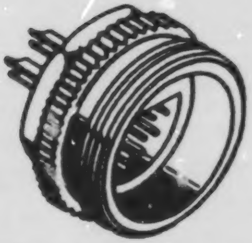


Splice

ELECTRICAL CONNECTORS

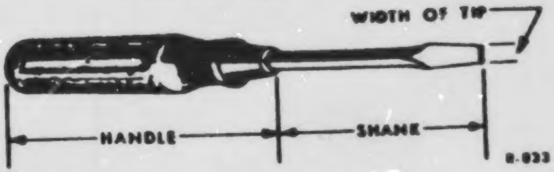


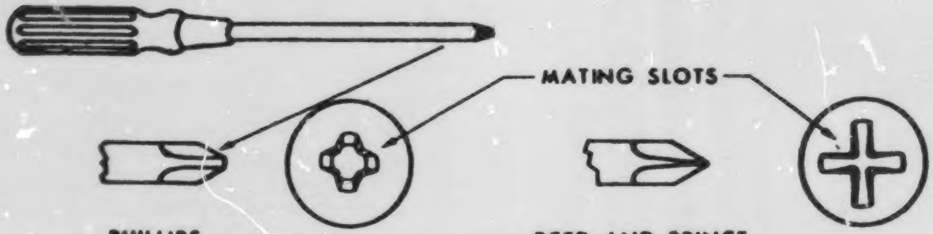
PLUG WITH SOCKET INSERT

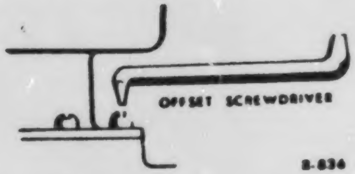


RECEPTACLE WITH PIN INSERT

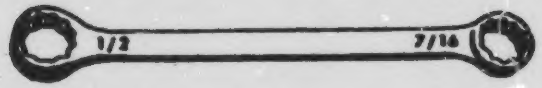
SCREWDRIVERS


WIDTH OF TIP
HANDLE
SHANK
B-833

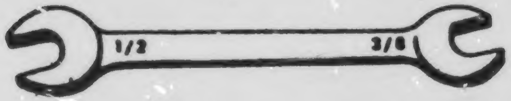

MATING SLOTS
PHILLIPS
REED AND PRINCE
B-835


OFFSET SCREWDRIVER
B-836

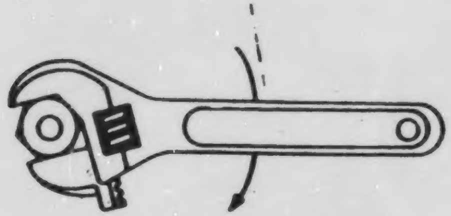
WRENCHES



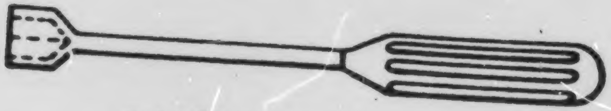
Box-End



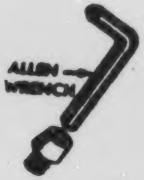
Open End

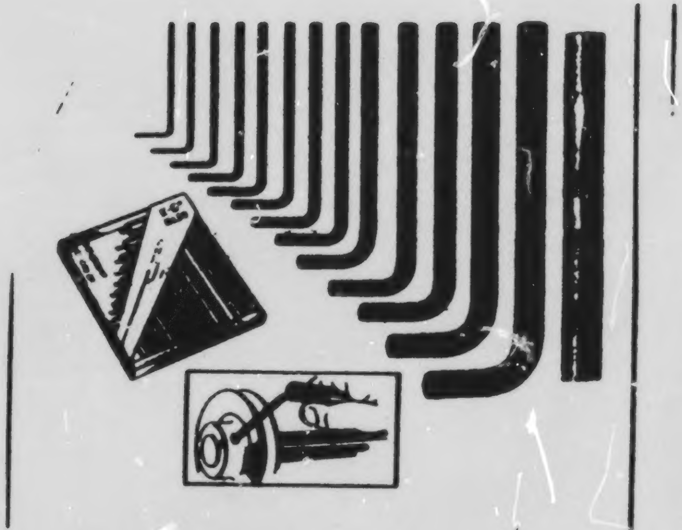


Adjustable Jaw

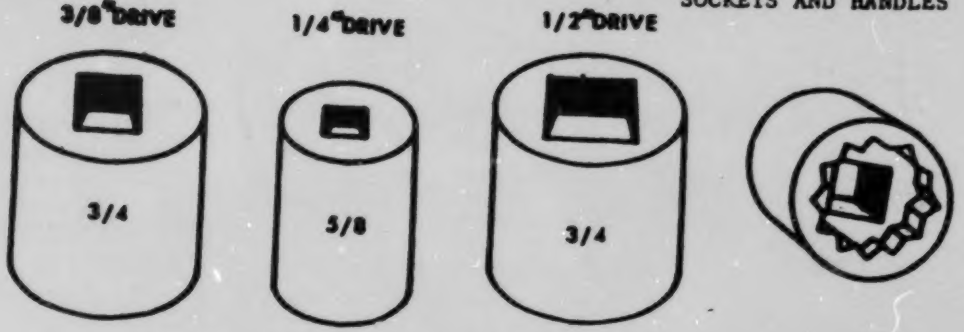


Spin-Tite

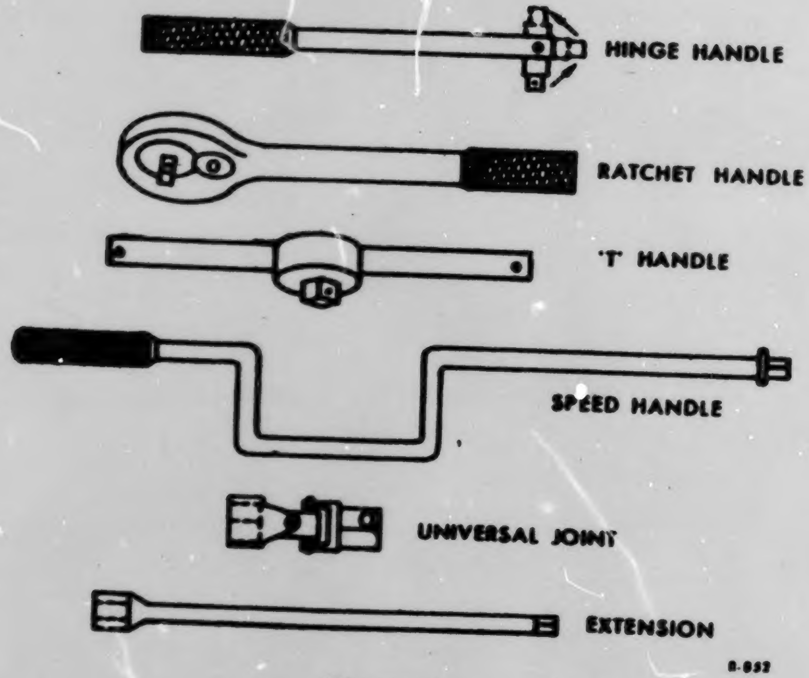

ALLEN WRENCH



SOCKETS AND HANDLES


3/8" DRIVE
1/4" DRIVE
1/2" DRIVE
3/4
5/8
3/4

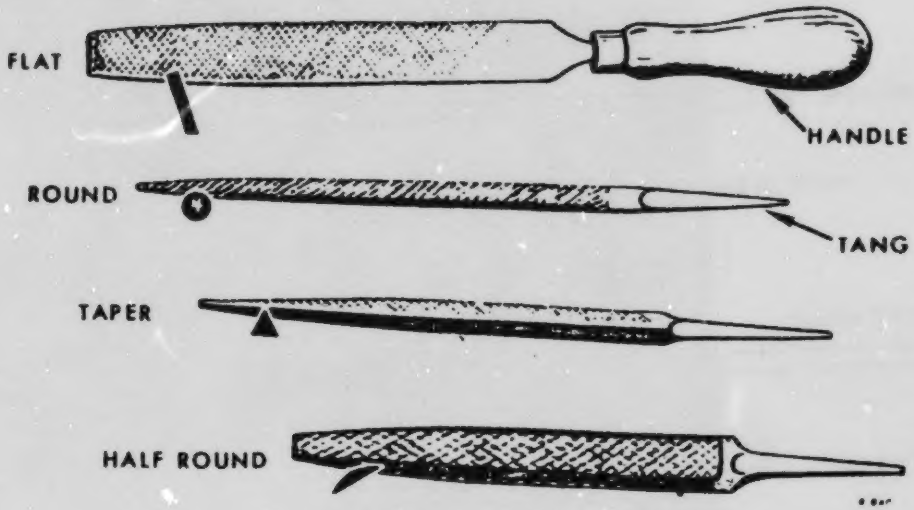
Sockets


HINGE HANDLE
RATCHET HANDLE
'T' HANDLE
SPEED HANDLE
UNIVERSAL JOINT
EXTENSION
8-852

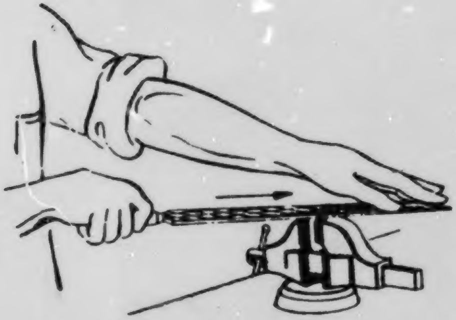
HANDLES

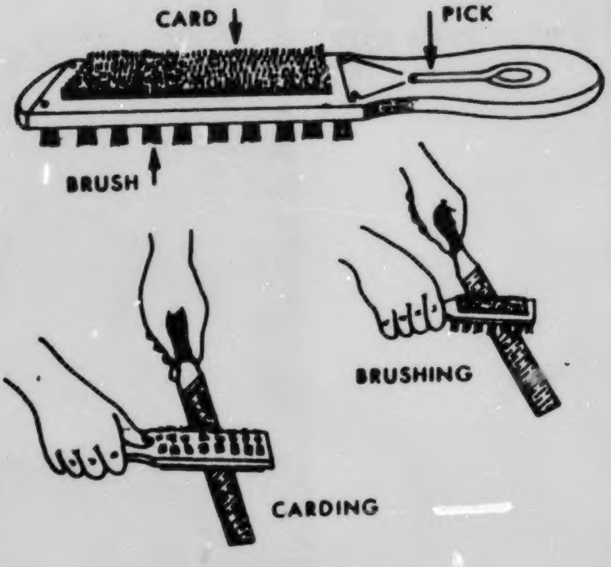
Figure 21.

FILES

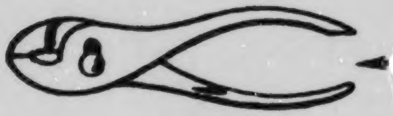

FLAT
HANDLE
ROUND
TANG
TAPER
HALF ROUND

CARE OF FILES

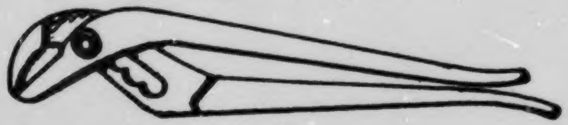



CARD
PICK
BRUSH
BRUSHING
CARDING

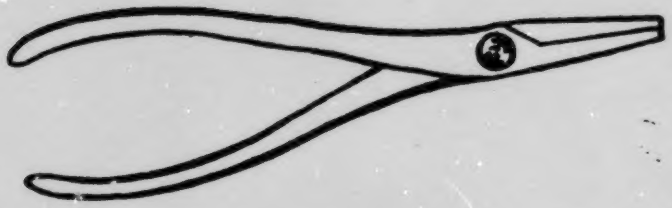
PLIERS



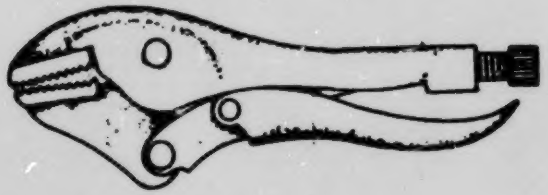
COMMON SLIP—JOINT



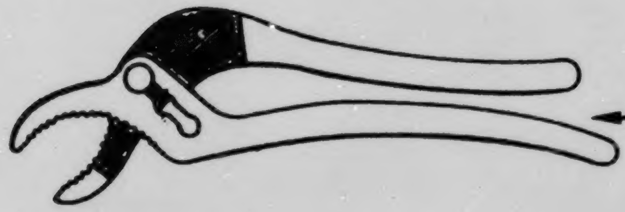
WATER PUMP



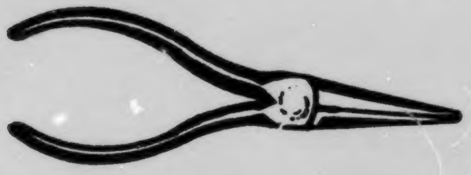
DUCKBILL PLIERS



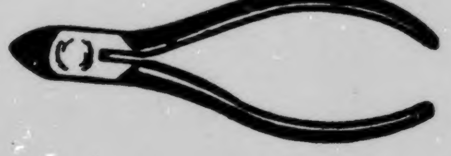
VISE - GRIP



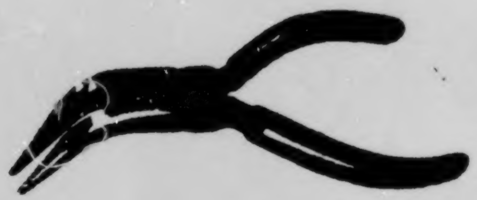
CONDUIT PLIERS



HALF ROUND NOSE PLIERS

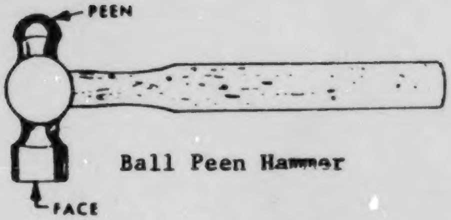


DIAGONAL CUTTING PLIERS

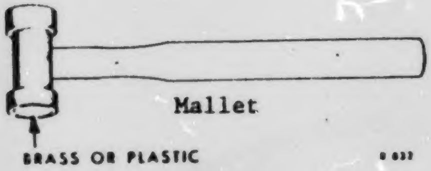


Offset Pliers

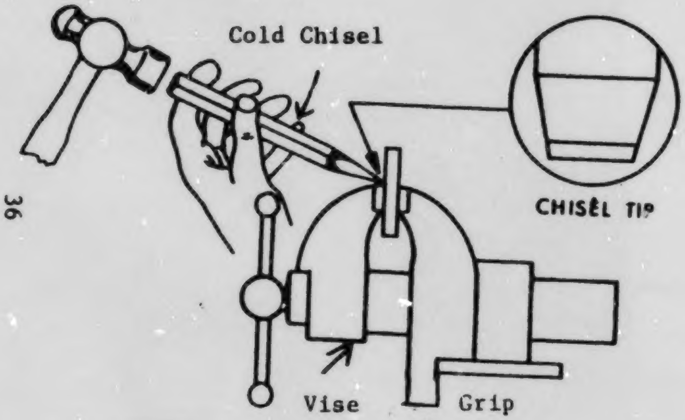
MISCELLANEOUS



Ball Peen Hammer

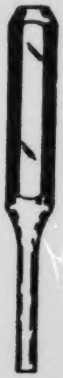

BRASS OR PLASTIC

Mallet

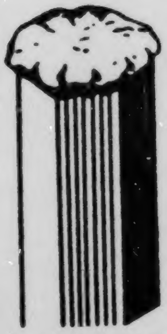

Cold Chisel
CHISEL TIP
Vise
Grip

36

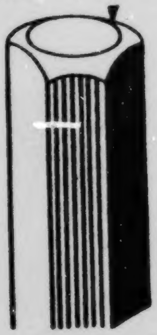
CENTER PUNCH



PIN PUNCH

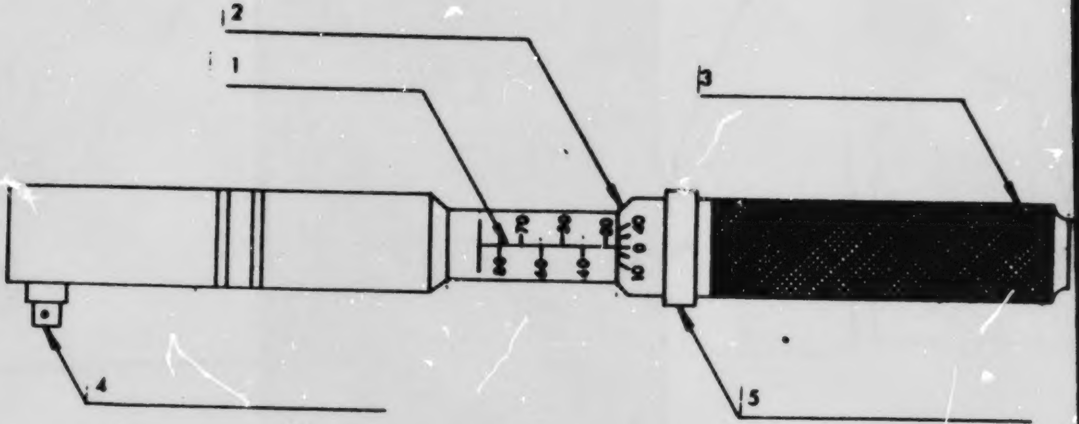


USHROOMED HEAD

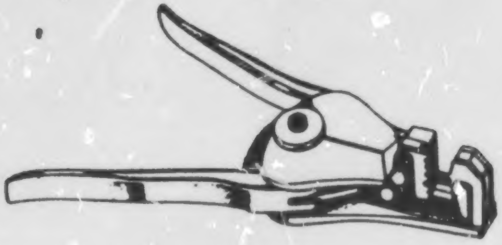


DRESSED HEAD

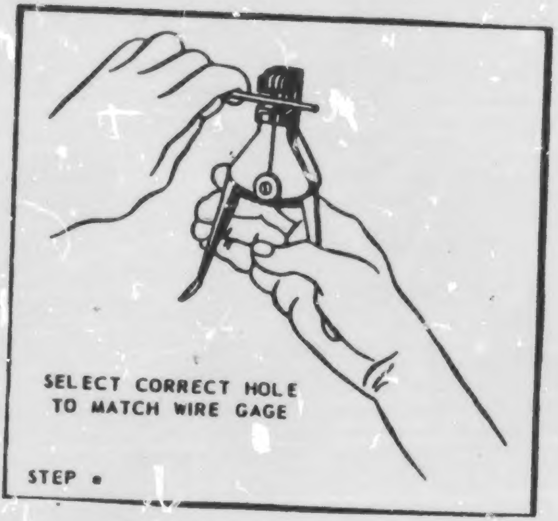
TORQUE WRENCH

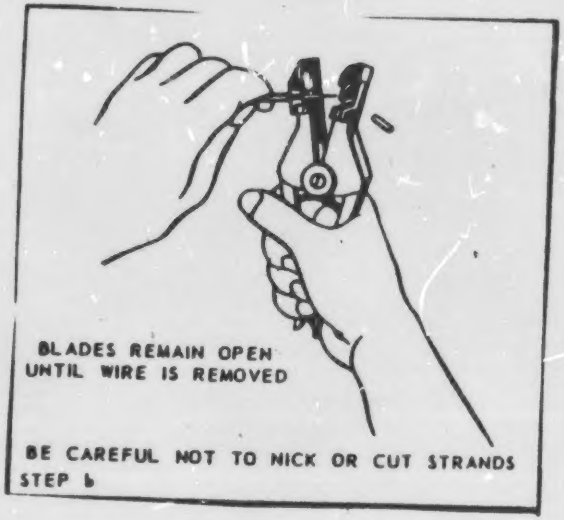


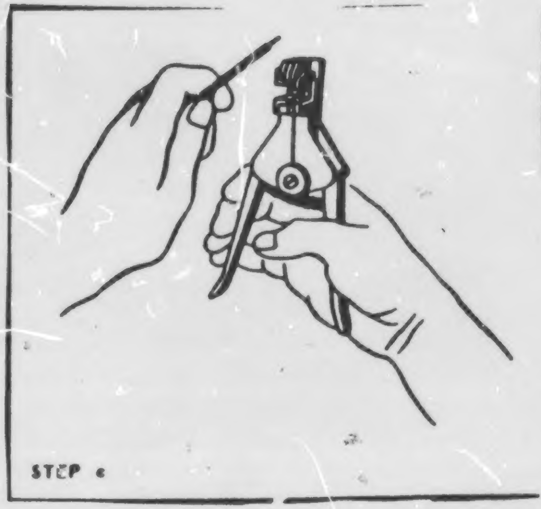
STRIPPERS



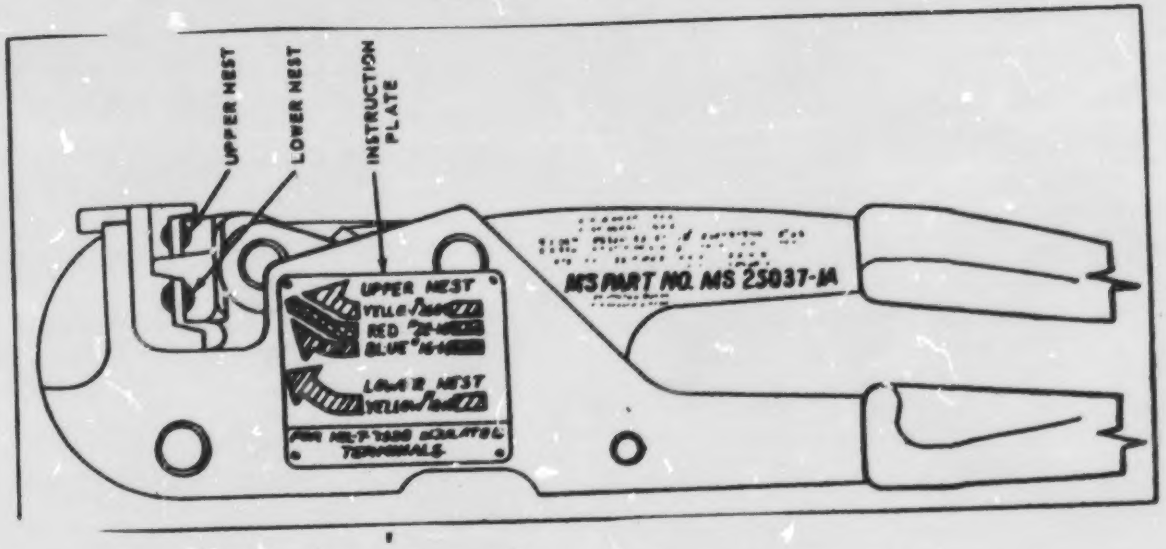
Wire strippers.

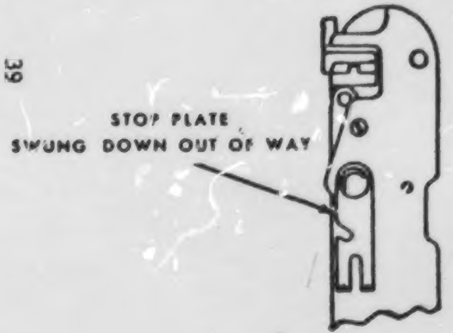

SELECT CORRECT HOLE
TO MATCH WIRE GAGE
STEP a


BLADES REMAIN OPEN
UNTIL WIRE IS REMOVED
BE CAREFUL NOT TO NICK OR CUT STRANDS
STEP b

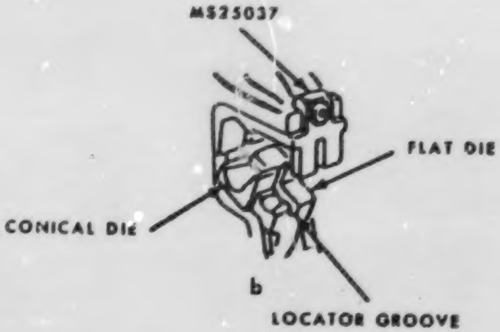


CRIMPERS

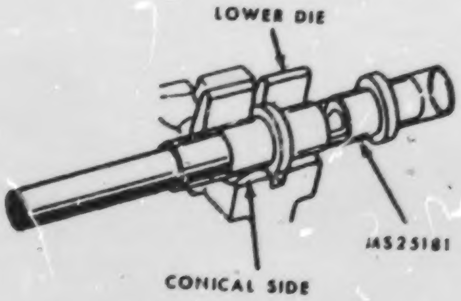

UPPER NEST
LOWER NEST
INSTRUCTION PLATE
UPPER NEST
RED
BLUE
LOWER NEST
TERMINALS
MS PART NO. MS 25037-1A


STOP PLATE
SWUNG DOWN OUT OF WAY

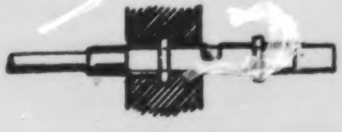
a


MS25037
FLAT DIE
CONICAL DIE
LOCATOR GROOVE

b


LOWER DIE
MS25181
CONICAL SIDE

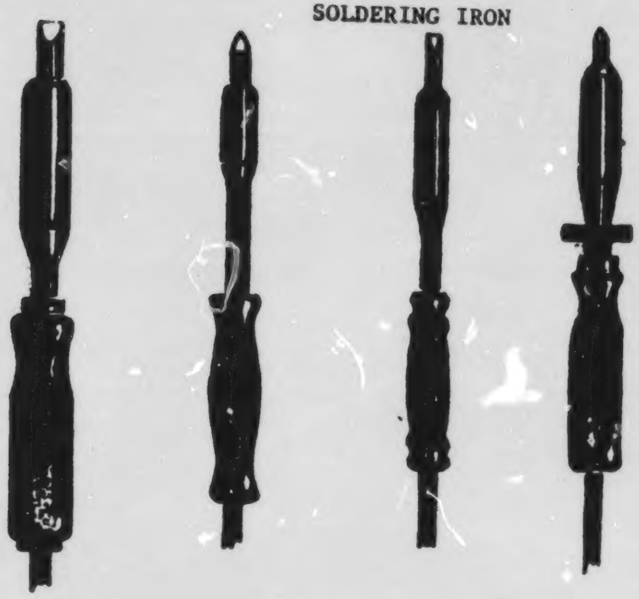
c

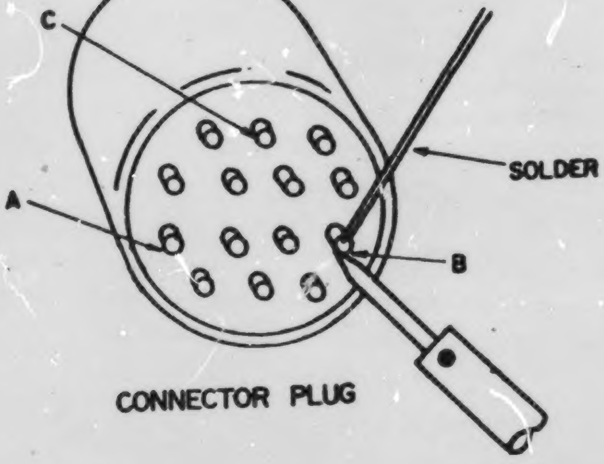


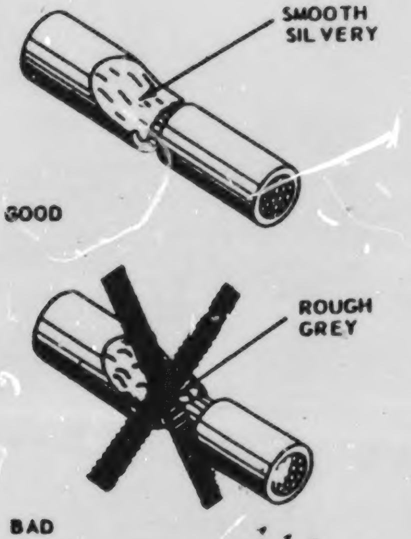
CORRECT

d

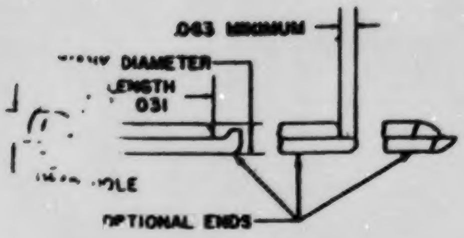
SOLDERING IRON



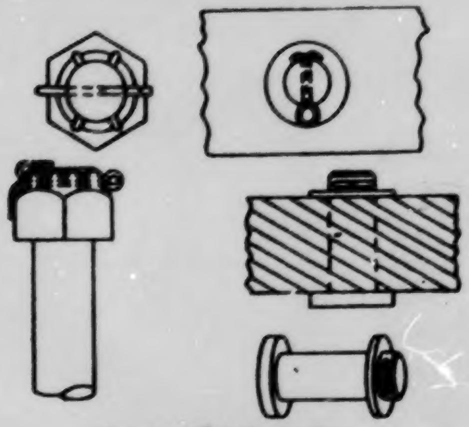

C
SOLDER
A
B
CONNECTOR PLUG


SMOOTH SILVERY
GOOD
ROUGH GREY
BAD

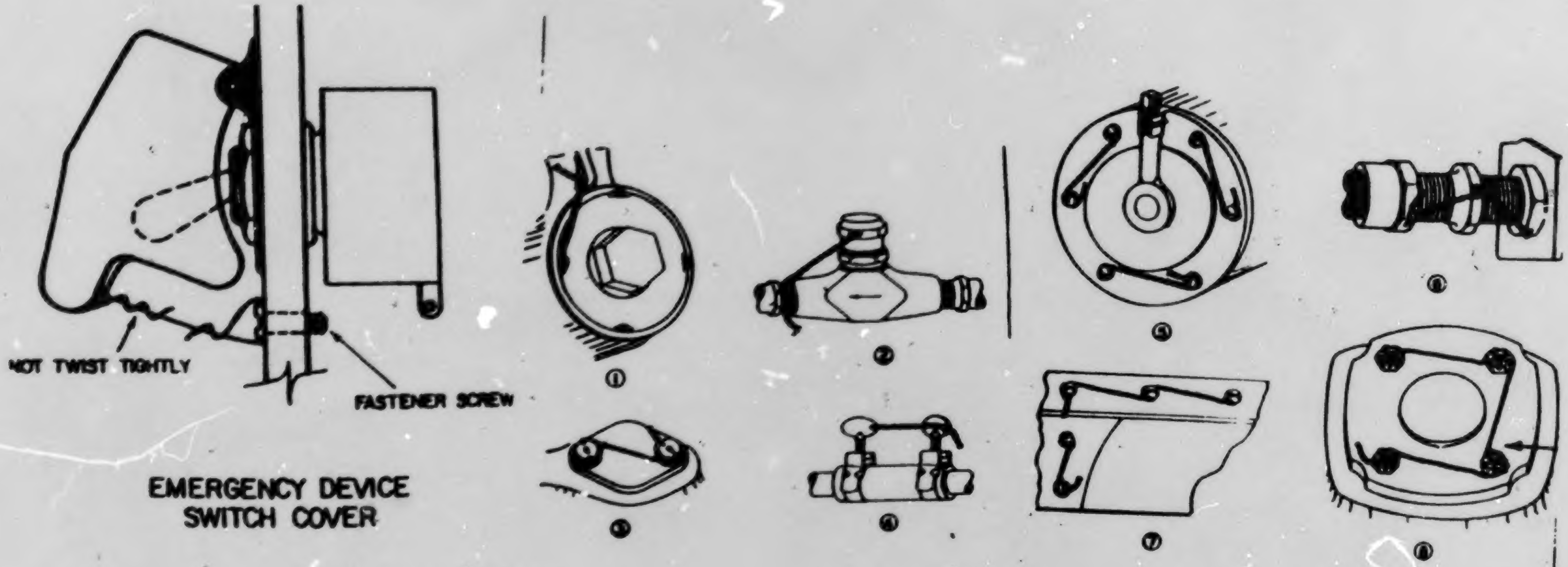
SAFETY[illegible]G


.063 MINIMUM
DIAMETER
LENGTH
.031
OLE
OPTIONAL ENDS

Cotter Pin



Securing With Cotter Pins


NOT TWIST TIGHTLY
FASTENER SCREW
EMERGENCY DEVICE SWITCH COVER
①
②
③
④
⑤
⑥
⑦
⑧

Safety Wiring

MAINTENANCE DATA COLLECTION RECORD

OMB NO.
21-R0227

1. JOB CONTROL NO.
2. WORKCENTER
3. I.D. NO./SERIAL NO.
4. MDS
5. EQ/CL
6. TIME
7. PRI
8. SORTIE NO.
9. LOCATION
10. ENG. TIME
11. ENGINE I.D.
12. INST ENG TIME
13. INST. ENG. I.D.
14.
15.
16.
17. TIME SPC REQ
18. JOB STD.
19. FSC
20. PART NUMBER
21. SER. NO./OPER. TIME
22. TAG NO.
23. INST. ITEM PART NO.
24. SERIAL NUMBER
25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	 HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDS ACTION

AFTO FORM MAY 75 349 PREVIOUS EDITION IS OBSOLETE.

*U.S.Government Printing Office: 1975 — 659-576

PAGE OF PAGES

DATE FROM / /	TO / /	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO.

SYM	DATE DISCD / /	WDC	JCN	TAG NO.	CF TO 781A P I	DATED / /	TRANSFERRED TO 781K DATE / /	TRANSFERRED BY

DISCREPANCY	CORRECTIVE ACTION
	DATE CORRECTED / /
ON	DISCOVERED BY
CORRECTED BY	INSPECTED BY

SYM	DATE DISCD / /	WDC	JCN	TAG NO.	CF TO 781A P I	DATED / /	TRANSFERRED TO 781K DATE / /	TRANSFERRED BY

DISCREPANCY	CORRECTIVE ACTION
	DATE CORRECTED / /
ON	DISCOVERED BY
CORRECTED BY	INSPECTED BY

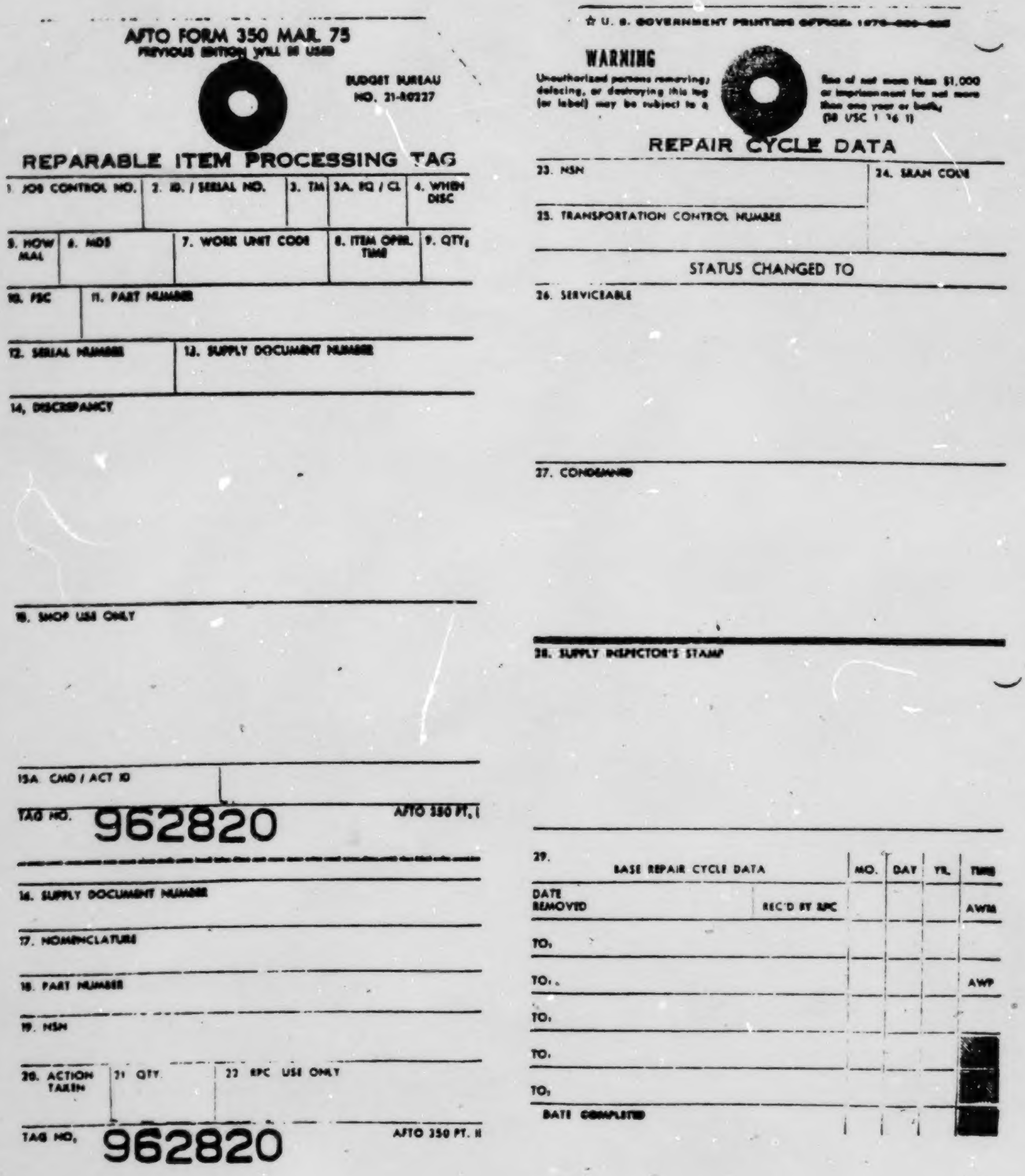
SYM	DATE DISCD / /	WDC	JCN	TAG NO.	CF TO 781A P I	DATED / /	TRANSFERRED TO 781K DATE / /	TRANSFERRED BY

DISCREPANCY	CORRECTIVE ACTION
	DATE CORRECTED / /
ON	DISCOVERED BY
CORRECTED BY	INSPECTED BY

SYM	DATE DISCD / /	WDC	JCN	TAG NO.	CF TO 781A P I	DATED / /	TRANSFERRED TO 781K DATE / /	TRANSFERRED BY

DISCREPANCY	CORRECTIVE ACTION
	DATE CORREC / /
ON	DISCOVERED BY
CORRECTED BY	INSPECTED BY

AFTO FORM MAY 73 781A **MAINTENANCE DISCREPANCY AND WORK DOCUMENT** 43 PREVIOUS EDITION



AFTO FORM 350 MAR. 75
PREVIOUS EDITION WILL BE USED

BUDGET BUREAU
NO. 21-R0227

REPARABLE ITEM PROCESSING TAG

1. JOB CONTROL NO.	2. ID. / SERIAL NO.	3. TM	3A. EQ / CL	4. WHEN DISC
5. HOW MAL	6. MDS	7. WORK UNIT CODE	8. ITEM OPER. TIME	9. QTY.

10. FSC

11. PART NUMBER

12. SERIAL NUMBER

13. SUPPLY DOCUMENT NUMBER

14. DISCREPANCY

15. SHOP USE ONLY

15A. CMD / ACT ID

TAG NO. 962820 AFTO 350 PT. I

16. SUPPLY DOCUMENT NUMBER

17. NOMENCLATURE

18. PART NUMBER

19. NSN

20. ACTION TAKEN

21. QTY.

22. RPC USE ONLY

TAG NO. 962820 AFTO 350 PT. II

☆ U. S. GOVERNMENT PRINTING OFFICE: 1975-[illegible]

WARNING

Unauthorized persons removing, defacing, or destroying this tag (or label) may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)

REPAIR CYCLE DATA

23. NSN

24. SRAN CODE

25. TRANSPORTATION CONTROL NUMBER

STATUS CHANGED TO

26. SERVICEABLE

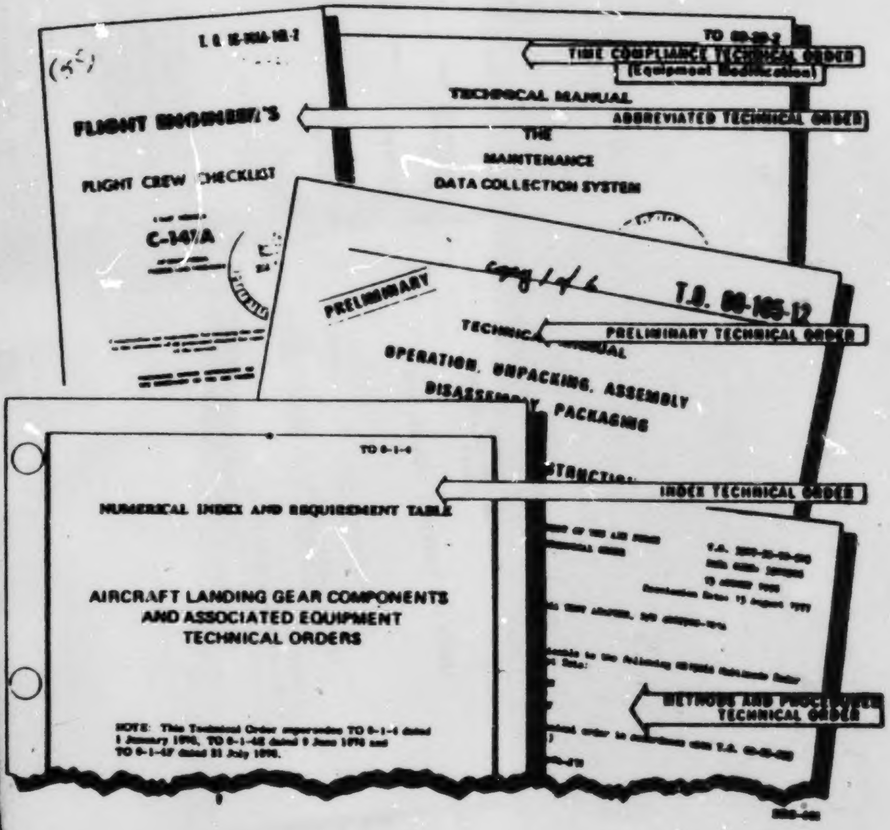
27. CONDEMNED

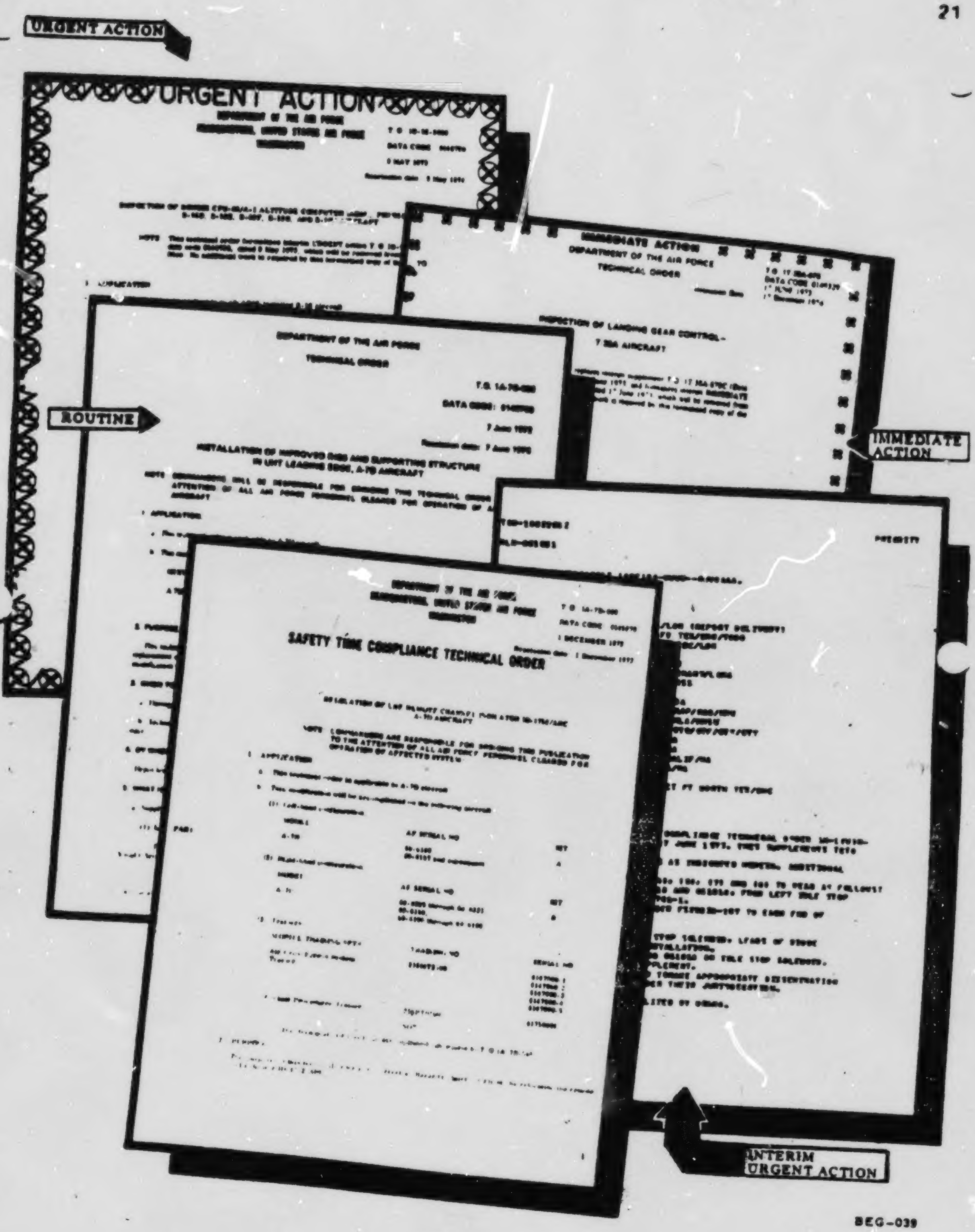
28. SUPPLY INSPECTOR'S STAMP

29.

BASE REPAIR CYCLE DATA		MO.	DAY	YR.	TIME
DATE REMOVED	REC'D BY RPC				AWM
TO:					
TO:					AWP
TO:					
TO:					
TO:					
DATE COMPLETED					

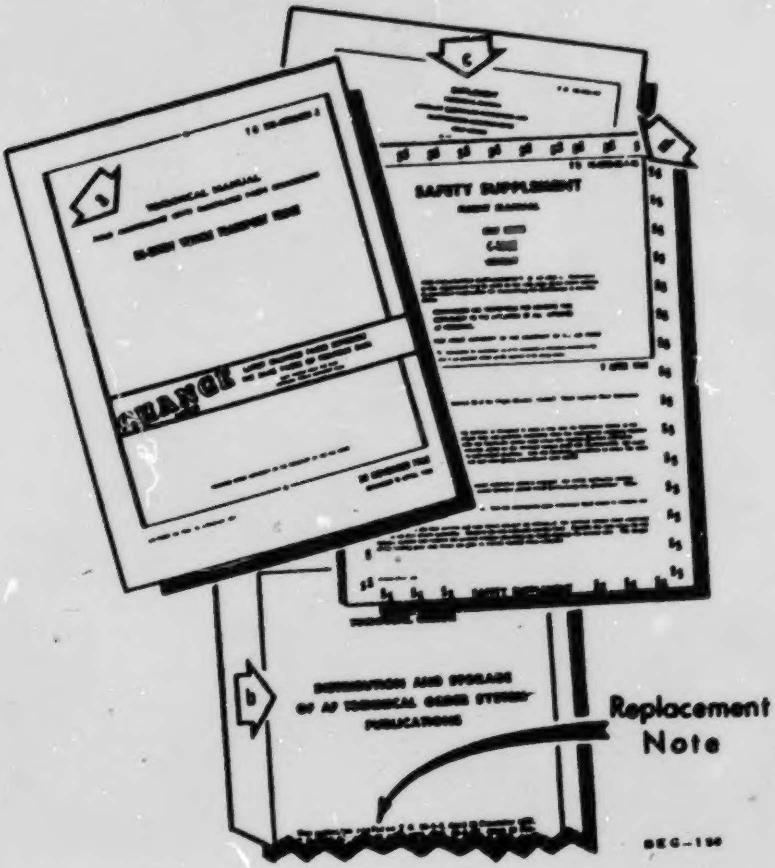
TYPES OF TECHNICAL ORDERS


TIME COMPLIANCE TECHNICAL ORDER
(Equipment Modification)
ABBREVIATED TECHNICAL ORDER
PRELIMINARY TECHNICAL ORDER
INDEX TECHNICAL ORDER
METHODS AND PROCEDURES TECHNICAL ORDER
FLIGHT ENGINEER'S
FLIGHT CREW CHECKLIST
C-141A
TECHNICAL MANUAL
THE MAINTENANCE DATA COLLECTION SYSTEM
PRELIMINARY
copy 1 of 6
T.O. 00-105-12
OPERATION, UNPACKING, ASSEMBLY
DISASSEMBLY, PACKAGING
TO 0-1-4
NUMERICAL INDEX AND REQUIREMENT TABLE
AIRCRAFT LANDING GEAR COMPONENTS AND ASSOCIATED EQUIPMENT TECHNICAL ORDERS


URGENT ACTION
URGENT ACTION
DEPARTMENT OF THE AIR FORCE
IMMEDIATE ACTION
DEPARTMENT OF THE AIR FORCE
TECHNICAL ORDER
INSPECTION OF LANDING GEAR CONTROL
ROUTINE
DEPARTMENT OF THE AIR FORCE
TECHNICAL ORDER
IMMEDIATE ACTION
PRIORITY
DEPARTMENT OF THE AIR FORCE
SAFETY TIME COMPLIANCE TECHNICAL ORDER
INTERIM URGENT ACTION

BEG-039

UPDATING TECHNICAL ORDERS


c
a
SAFETY SUPPLEMENT
CHANGE
b
DISTRIBUTION AND STORAGE OF AF TECHNICAL ORDER SYSTEM PUBLICATIONS
Replacement Note
BEG-130

LISTING FROM TECHNICAL ORDER INDEX

	21M-AIM9E-3-8 (C)	CONFIDENTIAL - O/M INSTR - CHAPTER 10, AIM9J ELECTRONIC COMPONENT TEST, REPAIR AND MATING FUNCTION (TITLE UNCL)(GDS EXEMPTION CATEGORY 3) - AIM9J	1 APR 73 CHG 1, 1 MAY 74	WR
S	21M-AIM9E-3-8S	SUPPL - TITLE SAME AS BASIC (RESC DATE 20 JAN 76)	20 JAN 75	WR
	21M-AIM9E-3-10 (U)	O/M INSTR - (VOLUME X OF X) - AIM-9E		WR
	21M-AIM9E-3-11 (U)	O/M INSTR - GUIDANCE AND CONTROL SECTION (PHILCO FORD) - AIM9B,E,J		WR

BEG-300

TECHNICAL ORDER SYSTEM PUBLICATION IMPROVEMENT REPORT AND REPLY

FORM APPROVED
OMB NO. 21–R0307

1. TO: *(Major Command or equivalent)* ATC/TTRE

2. TO: *(Organ having Mgmt Responsibility for the T.O.)* Ogden ALC/ MMSTA

3. FROM *(Organ reporting)* SAAS/TTGTC

4. REPORT DATE: YR 77, MO 06, DAY 01

5. BASIC DATE OF T.O.: 1 May 72

6. DATE OF T.O. CHANGE: 15 Jan76

7. PAGE NUMBER: 1-1

8. PARAGRAPH NUMBER: 1-3

9. FIGURE NUMBER:

DOC IDENT	T O		TECHNICAL ORDER NUMBER	IMPROVEMENT REPORT NUMBER
1–3	4	5	6–30	31–45
X Y A	H		1 F - 4C -2 - 19 -1	

10. BRIEF SUMMARY OF DEFICIENCY AND RECOMMENDED CHANGE *(Use continuation sheets if necessary)*

11. REPORTED BY *(Initiator's Signature, OAS and Extension)*

12. APPROVED BY *(Supervisor's Signature)*

13. QUALITY CONTROL *(Signature)*

14. MAJOR COMMAND ACTION

15. *(Check applicable block)* ☐ APPROVED ☐ DISAPPROVED

16. SIGNATURE *(Major Command Authority)*

17. DATE

	TR CODE			DATE RECEIVED						DATE TO MGR							TRANSFER CODE						(Reserved)
				YR		MO		DAY		YR		MO		DAY									
☐	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68–80
	D	A	A																				

	TR CODE			DATE FROM MGR						ACTION TAKEN	RESOLUTION DATE						(Reserved)
				YR		MO		DAY			YR		MO		DAY		
☐	46	47	48	49	50	51	52	53	54	55–66	67	68	69	70	71	72	73–80
	B	B	A														

18. TO: *(Major Command or equivalent)*

19. TO: *(Organization Reporting Improvement)*

20. FROM *(SM/SE)*

21. REMARKS *Use continuation sheets if necessary)*

22. DATE OF REPLY

23. REPLY BY *(Signature, OAS, Extension)*

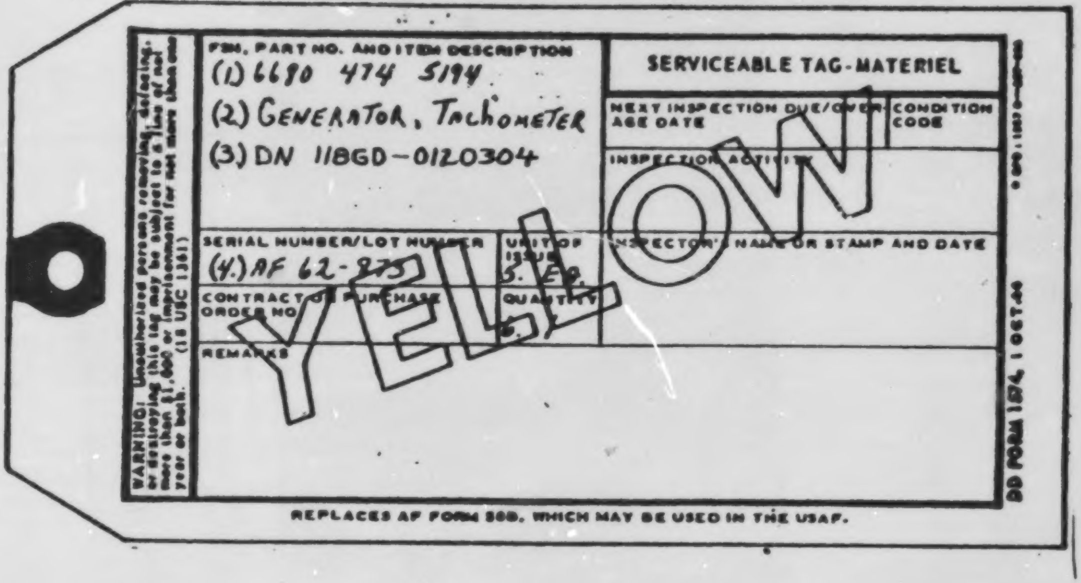
24. APPROVED BY *(Supervisor)*

AFTO FORM APR 73 22

REPLACES AFTO FORMS 22 AND 22A WHICH ARE OBSOLETE

SEA–22

STATUS TAGS



WARNING: Unauthorized persons removing, defacing, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)

FSN, PART NO. AND ITEM DESCRIPTION
(1) 6690 474 5194
(2) GENERATOR, TACHOMETER
(3) DN 118GD-0120304

SERVICEABLE TAG-MATERIEL

NEXT INSPECTION DUE/OVERAGE DATE

CONDITION CODE

INSPECTION ACTIVITY

SERIAL NUMBER/LOT NUMBER (4.) AF 62-275

UNIT OF ISSUE 5. EA.

INSPECTOR'S NAME OR STAMP AND DATE

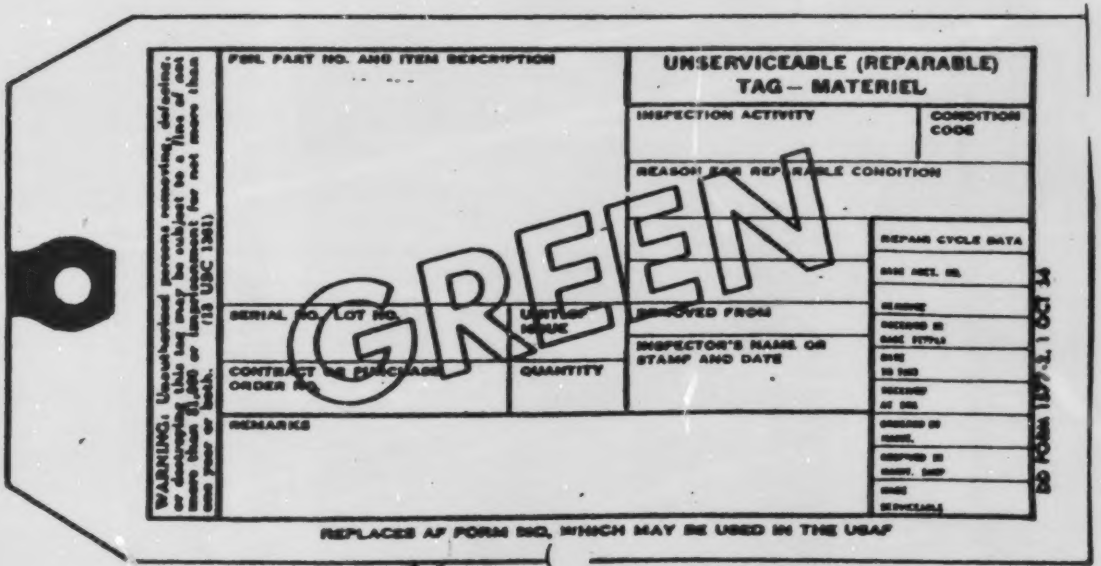
CONTRACT OR PURCHASE ORDER NO

QUANTITY 6.

REMARKS

DD FORM 1574, 1 OCT 64

REPLACES AF FORM 30B, WHICH MAY BE USED IN THE USAF.



WARNING: Unauthorized persons removing, defacing, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)

FSN, PART NO. AND ITEM DESCRIPTION

UNSERVICEABLE (REPARABLE) TAG — MATERIEL

INSPECTION ACTIVITY

CONDITION CODE

REASON FOR REPARABLE CONDITION

REPAIR CYCLE DATA

SERIAL NO./LOT NO.

UNIT OF ISSUE

REMOVED FROM

INSPECTOR'S NAME OR STAMP AND DATE

CONTRACT OR PURCHASE ORDER NO.

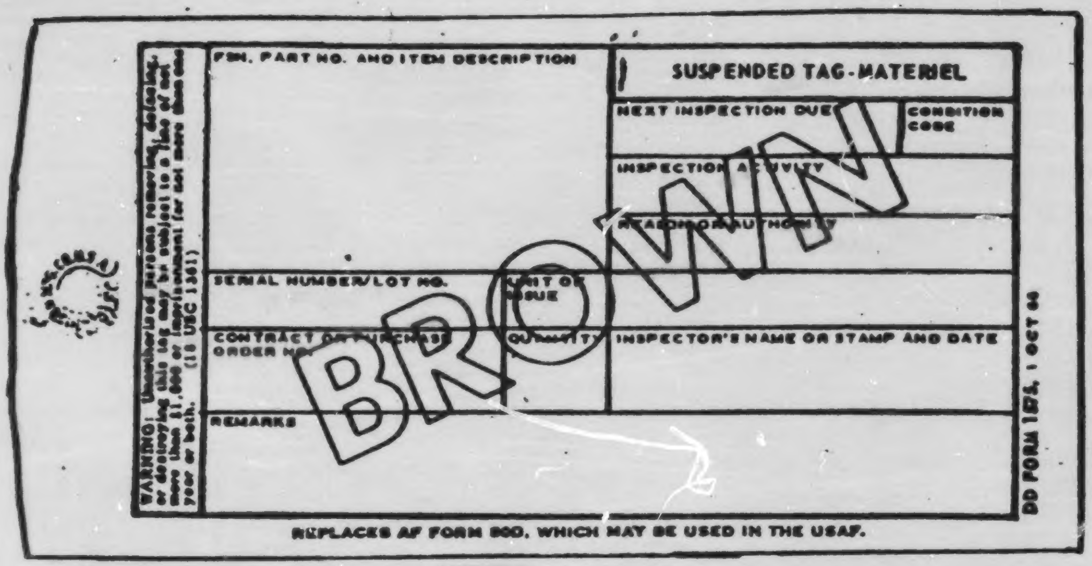
QUANTITY

REMARKS

DD FORM 1577-2, 1 OCT 64

REPLACES AF FORM 30D, WHICH MAY BE USED IN THE USAF

STATUS TAGS



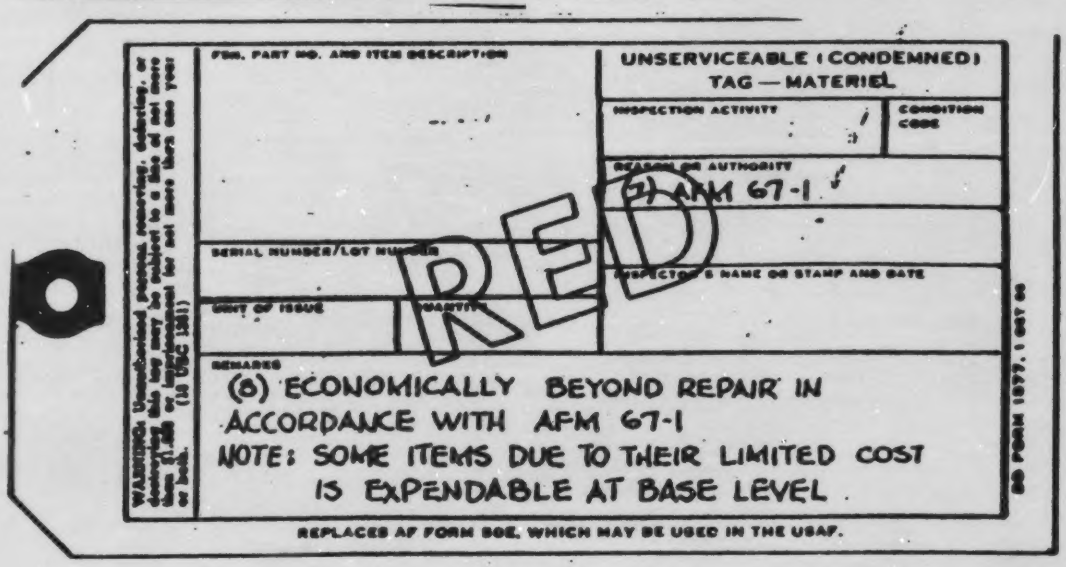
WARNING: Unauthorized persons removing, deleting, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)

FSN, PART NO. AND ITEM DESCRIPTION	SUSPENDED TAG-MATERIEL
	NEXT INSPECTION DUE
	CONDITION CODE
	INSPECTION ACTIVITY
	REASON OR AUTHORITY
SERIAL NUMBER/LOT NO.	UNIT OF ISSUE
CONTRACT OR PURCHASE ORDER NO.	QUANTITY
	INSPECTOR'S NAME OR STAMP AND DATE
REMARKS	

BROWN

DD FORM 1575, 1 OCT 56

REPLACES AF FORM 80D, WHICH MAY BE USED IN THE USAF.



WARNING: Unauthorized persons removing, deleting, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)

FSN, PART NO. AND ITEM DESCRIPTION	UNSERVICEABLE (CONDEMNED) TAG — MATERIEL
	INSPECTION ACTIVITY
	CONDITION CODE
	REASON OR AUTHORITY (7) AFM 67-1
SERIAL NUMBER/LOT NUMBER	
UNIT OF ISSUE	QUANTITY
	INSPECTOR'S NAME OR STAMP AND DATE

REMARKS

(8) ECONOMICALLY BEYOND REPAIR IN ACCORDANCE WITH AFM 67-1

NOTE: SOME ITEMS DUE TO THEIR LIMITED COST IS EXPENDABLE AT BASE LEVEL.

RED

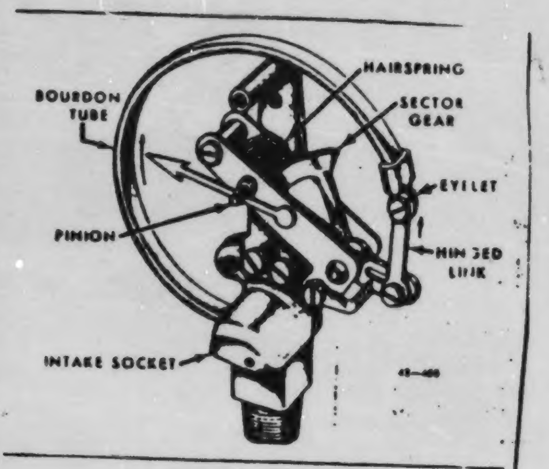
DD FORM 1577, 1 OCT 56

REPLACES AF FORM 80E, WHICH MAY BE USED IN THE USAF.

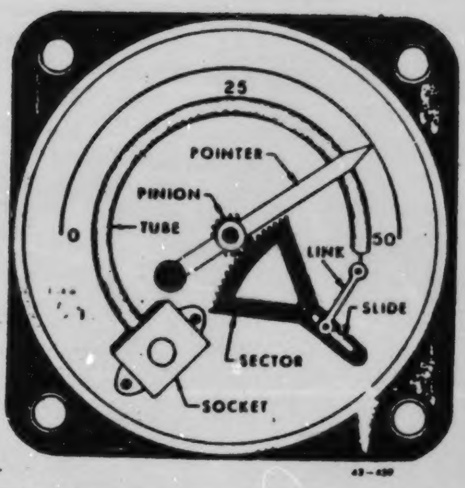
SAMPLE

CLASSIFICATION GUIDE

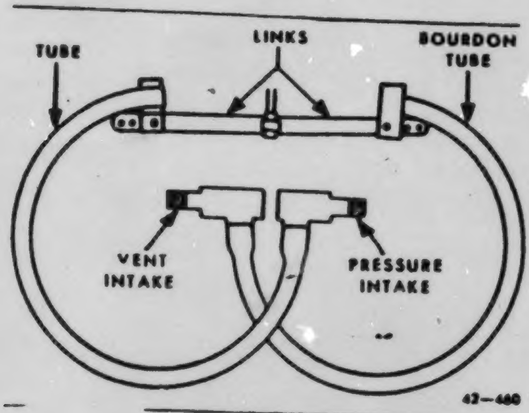
	I Classify TOP SECRET if disclosure could:	II Classify SECRET if disclosure could:	III Classify CONFIDENTIAL if disclosure could:	IV Mark FOR OFFICIAL USE ONLY if disclosure could:
A Intelligence Efforts	reveal own success and or capabilities by allowing full evaluation of effort.	reveal facts we know: potential enemy material, troop dispositions, etc	compromise some intelligence and counter intelligence reports.	reveal information furnished by foreign nations in confidence.
B Weapon Systems	(1) disclose nuclear data, (2) compromise radically new and extremely important equipment.	compromise data relating to new developments	reveal production and procurement of munitions. - - - - - - - - some technical training manuals.	reveal certain technical data relating to arms which are subject to export licensing.
C Force composition and Deployment	compromise world-wide composition and deployment in war plans.	reveal strength, identity, equipment, composition, and location of units engaged in hostilities	reveal strength of ground, naval, and air forces in the U.S. and overseas.	reveal information pertaining to specific unit identification, current location, and general nature of equipment. - - - - - - - - - orders to an area of undeclared war.
D Political-Military Information	(1) lead to a definite break in diplomatic relations. (2) result in an armed attack against the U.S. or its allies.	jeopardize international relations.		
E Operations	compromise strategic plan documenting overall conduct of war.	compromise plans that reveal military capability or preparedness	reveal operational and technical doctrine/ - - - - - - - - - - radio frequencies and call signs of special significance.	SAMPLE


HAIRSPRING
BOURDON TUBE
SECTOR GEAR
EYELET
PINION
HINGED LINK
INTAKE SOCKET

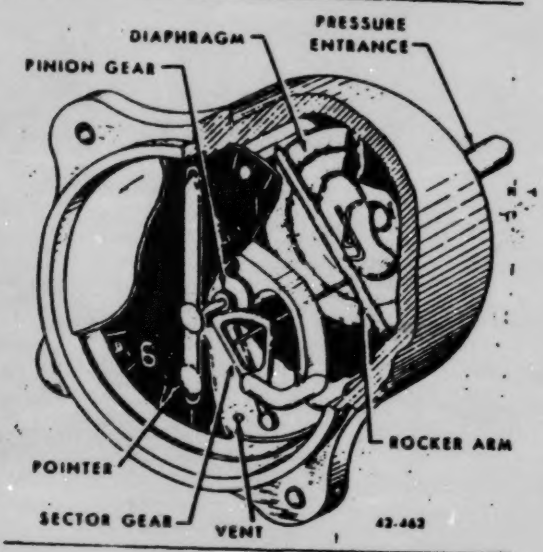
Bourdon tube sensitive element.


25
POINTER
PINION
0
TUBE
50
LINK
SLIDE
SECTOR
SOCKET

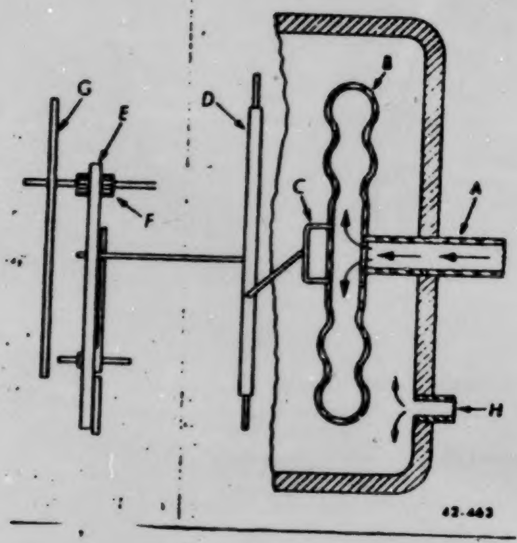
Typical bourdon tube pressure gage.


TUBE
LINKS
BOURDON TUBE
VENT INTAKE
PRESSURE INTAKE
42-480

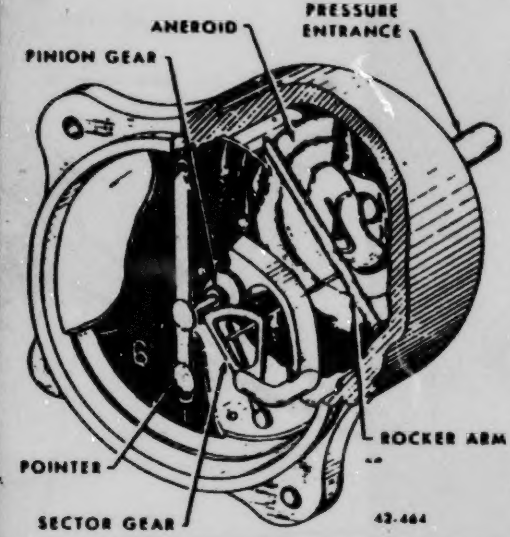
Dual bourdon tube arrangement.


PRESSURE ENTRANCE
DIAPHRAGM
PINION GEAR
ROCKER ARM
POINTER
SECTOR GEAR
VENT
42-462

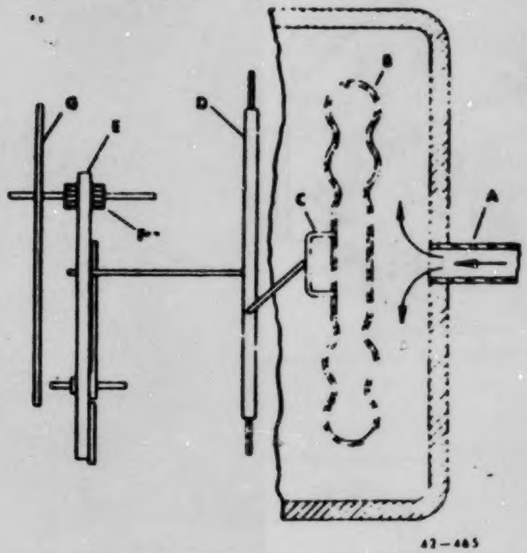
Cutaway of diaphram mechanism.


G
E
D
B
C
A
F
H
42-463

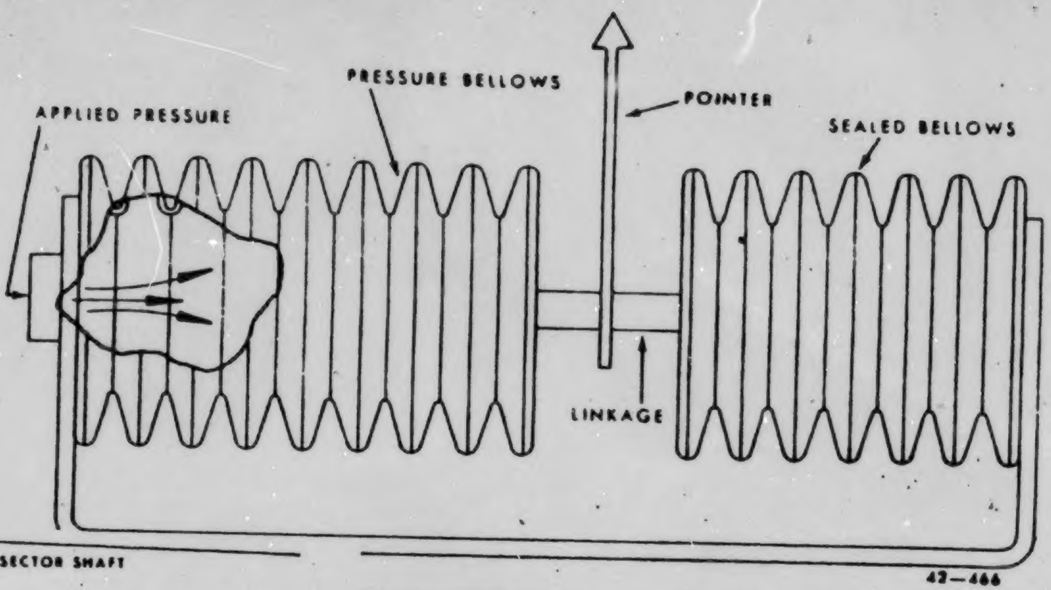
Cross-section of a diaphram.


PRESSURE ENTRANCE
ANEROID
PINION GEAR
ROCKER ARM
POINTER
SECTOR GEAR
42-464

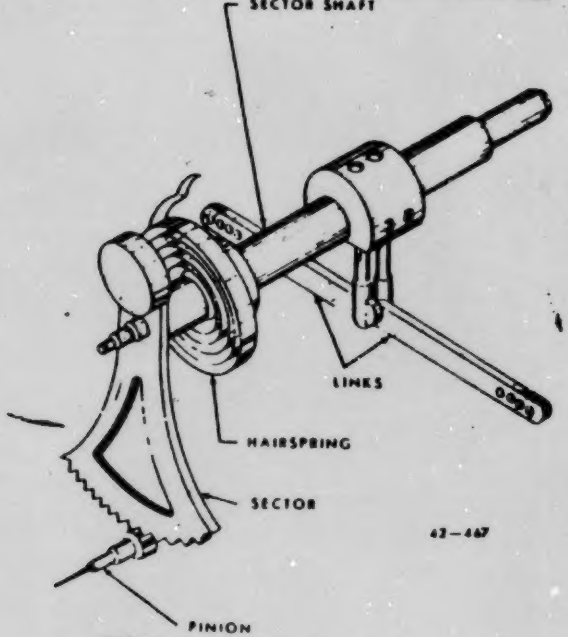
Cutaway of an aneroid mechanism.


G
E
D
B
F
C
A
42-465

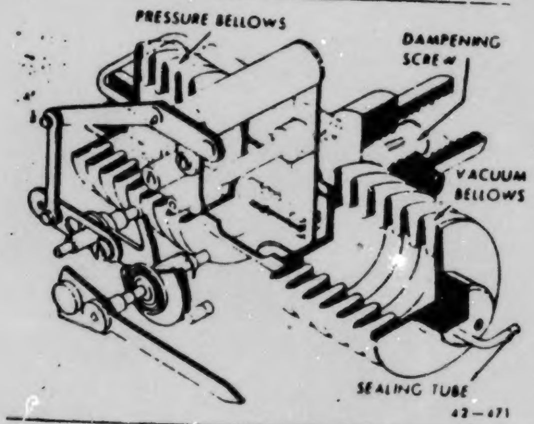
Cross-section of an aneroid mechanism.


APPLIED PRESSURE
PRESSURE BELLOWS
POINTER
SEALED BELLOWS
LINKAGE
42—466

-9. Simplified dual bellows mechanism.


SECTOR SHAFT
LINKS
HAIRSPRING
SECTOR
PINION
42—467

Dual linkage arrangement.


PRESSURE BELLOWS
DAMPENING SCREW
VACUUM BELLOWS
SEALING TUBE
42—471

Typical dual-bellows assembly.

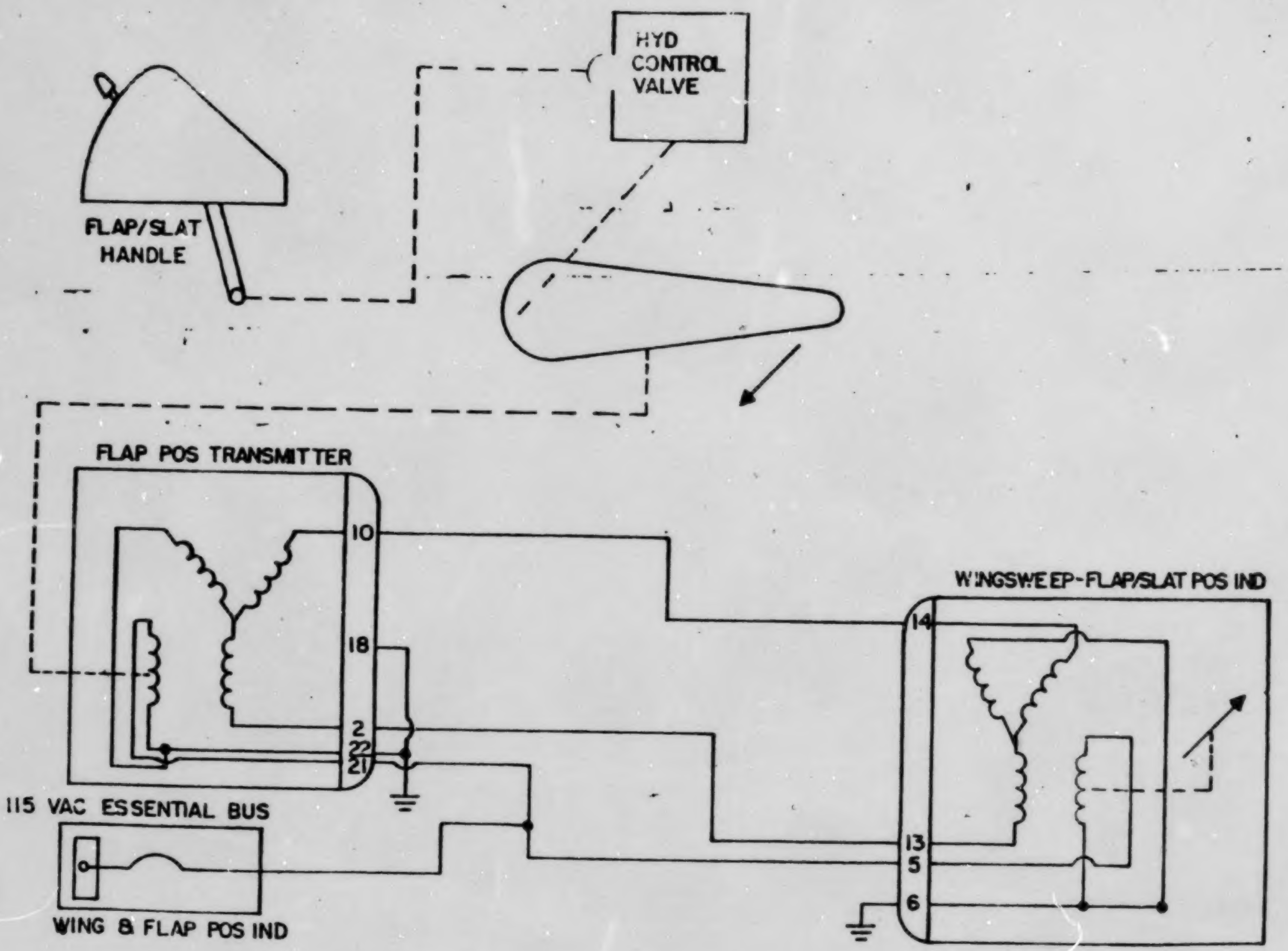

HYD CONTROL VALVE
FLAP/SLAT HANDLE
FLAP POS TRANSMITTER
115 VAC ESSENTIAL BUS
WING & FLAP POS IND
WINGSWEEP-FLAP/SLAT POS IND

Figure 2.

PROGRAMMED TEXT
3ABR32632B-PT-202
3ABR32530-1-PT-103
3ABR32531-PT-103
3ABR34133-PT-106
3ABR34134-PT-201

Technical Training

Integrated Avionics System Specialist
Automatic Flight Control System Specialist
Avionics Instrument System Specialist
Analog Flight Simulator Specialist
Digital Flight Simulator Specialist

AIRCRAFT FAMILIARIZATION

22 August 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

113

FOREWORD

This programmed text was prepared for use in the Automatic Flight Control System Specialist Course 3ABR32530-1. The material contained herein was validated by twenty (20) students from the subject course. At least 90% of the students achieved the objective as stated below.

OBJECTIVE

1. Without references, identify facts concerning aircraft familiarization. An accuracy of 70% is required.

   a. Types and distinguishing characteristics.

   b. Principles of flight and flight controls.

   c. Structural areas and systems.

INSTRUCTIONS

This programmed text presents information in small steps called frames. Within each frame, you are asked to respond to a situation or question. Read the information given and respond by circling the correct letter or in some other manner as instructed in the frame. After you have made your response, compare your answers to those given at the top of every other frame. Example, the answers for frame 1 are at the top of frame 3; and the answers to frame 2 are at the top of frame 4, etc. If your answer is correct, go to the next frame; if your answer is wrong, read the frame again to get the information straight in your mind. Write the correct response next to your original response, and then proceed to the next frame. Work at your own pace. DO NOT HURRY!

Supersedes 3ABR32530-1-PT-115, 3ABR32531-PT-104, 3ABR32632B-PT-203, 3ABR34230-PT-606A, 2 January 1974.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360TCHTG/TTGU-F - 200; TTVSA - 1

Frame 1

All military aircraft are assigned a group of numbers and letters for identification purposes. Listed below are some typical examples.

A-1E

B-52H

C-135A

F-106B

H-3C

T-33A

U-6A

X-15A

The letter in front of the dash indicates the basic mission for which the aircraft was designed. This letter is referred to as the basic mission symbol. The basic mission symbol is used to denote the primary function of capability of the aircraft. Special cases are the letters "H" and "V." The "H" stands for helicopter - a type of aircraft with rotary wings. The helicopter is capable of flight both horizontally and vertically. The "V" stands for either vertical takeoff or landing (VTOL) or short takeoff or landing (STOL) type aircraft which are designed for taking off or landing in very short distances.

Mark the following statements true (T) or false (F).

_____1. A B-52H is a helicopter.

_____2. A T-33A is a fixed wing aircraft.

_____3. In the designation U-6A, the A indicates the basic mission of the aircraft.

_____4. An H-3C is a rotary wing aircraft.

_____5. A V-10A would be the proper designation for a short takeoff or landing aircraft.

Frame 7

Military aircraft are designed to perform a primary function or job. As you have already learned, the basic mission letter is assigned to all military aircraft to denote the primary function or basic mission for which it is designed. A partial list of basic missions and their respective mission letters is shown below.

A - Attack

B - Bomber

C - Cargo/Transport

F - Fighter

O - Observation

T - Trainer

U - Utility

X - Experimental/Research

Notice that the basic mission letter is usually the first letter of the word representing the basic mission.

Mark the following statements true (T) or false (F).

_____1. The basic mission letter for a utility aircraft is "U."

_____2. The basic mission letter stands for the primary function for which the aircraft is designed.

_____3. "T" is the basic mission letter for transport.

Answers to Frame 1: __F__ 1. __T__ 2. __F__ 3. __T__ 4. __T__ 5.

Frame 3

Let's learn more about basic missions of various aircraft and their distinguishing characteristics. An attack aircraft is designed to search out and destroy enemy land or sea targets, its armament is cannon and air to surface rockets.

Fighter aircraft are similar in size and shape to attack aircraft. Fighters are designed to intercept and destroy other aircraft and missiles. Some fighters are also multipurpose aircraft designed to support friendly troops in the destruction of enemy troops and equipment. The distinguishing characteristics of fighters and attack aircraft, as compared to bombers and cargo aircraft, are their small size and thin, short wings. Fighter armament is usually cannon and air to air rockets.

Mark the following statements true (T) or false (F).

_____1. Attack aircraft usually carry air to air missiles.

_____2. Fighter aircraft are used to engage enemy aircraft and support friendly troops.

_____3. Most fighter aircraft have thick wings and large fuselages.

Answers to Frame 2: __T__ 1. __T__ 2. __F__ 3.

Frame 4

Bomber aircraft are designed to carry heavy bomb loads far into enemy territory. They are equipped with all-weather flying and bombing equipment. Many of the distinguishing characteristics of bomber type aircraft also exist on cargo/transport type aircraft.

Cargo aircraft are designed to carry heavy loads of cargo and/or passengers. Instead of bomb-bay doors in the bottom of the plane as is the case with bombers, modern cargo aircraft have loading doors at the front or rear of their roomy fuselages to accommodate loading freight or vehicles. Loading ramps, conveyors, and hoists aid in loading and unloading heavy cargo. Obviously, one distinguishing characteristic of both bomber and cargo-type aircraft is their huge size.

Mark the following statements true (T) or false (F).

_____1. Bombers have doors in the bottom of the aircraft to load and drop or unload bombs.

_____2. Bombers are used to carry cargo and/or passengers.

_____3. Transports can carry vehicles.

_____4. Cargo aircraft are generally small and fast.

Answers to Frame 3: __F__1. __T__2. __F__3.

Frame 5

Observation aircraft are designed to fly over enemy territory to obtain information concerning enemy troops and supplies in active combat areas.

Trainer aircraft are designed for training personnel to operate the aircraft and/or related equipment. A distinguishing characteristic of the trainer type aircraft is the two-seat cockpit - either side-by-side or in tandem (one behind the other).

Aircraft used for miscellaneous missions such as carrying small cargo loads and/or passengers, towing targets, etc., are designated as utility aircraft and are assigned the mission letter "U."

Mark the following statements true (T) or false (F).

_____1. Observation aircraft are used to observe enemy troop movement.

_____2. Trainer aircraft are designed primarily to test new equipment.

_____3. The U-2A is a utility aircraft.

119

Answers to Frame 4: _T_ 1. _F_ 2. _T_ 3. _F_ 4.

Frame 6

Sometimes aircraft are modified to perform functions other than their primary function. Some bombers, for example, are modified for reconnaissance; some cargo aircraft are modified to provide inflight refueling of other aircraft, etc. When an aircraft has been modified, it is identified by a modified mission letter placed in front (to the left) of the basic mission letter. Some examples of modified mission letters are listed below.

A - Aircraft modified to attack enemy troops and targets.

C - Aircraft modified to carry cargo and personnel.

H - Aircraft having special equipment to perform search and rescue missions.

K - Aircraft modified to perform inflight refueling (tanker).

T - Aircraft modified for training purposes.

R - Aircraft equipped for photographic or electronic reconnaissance missions.

U - Usually small aircraft modified to carry cargo, passengers, or tow targets.

W - Aircraft modified with permanently installed weather equipment.

Remember, if an aircraft number has only one prefix letter on the left, then the aircraft is performing its basic mission. If, however, the number begins with two letters, the outside (left most) letter indicates the mission which the aircraft is modified to perform.

Mark the following statements true (T) or false (F).

_____1. An RB-57 aircraft is designed for a basic mission of bombing.

_____2. The modified mission letter of the KC-135 is "K."

_____3. The modified mission of an HU-16 aircraft is search and rescue.

141

Answers to Frame 5: __T__1. __F__2. __T__3.

Frame 7

Military aircraft are further identified by design number as follows:

Attack aircraft - A-1, A-3, A-4, A-5, etc.

Bomber aircraft - B-25, B-26, B-47, B-52, etc.

Cargo/Transport aircraft - C-47, C-54, C-130, C-135, etc.

Fighter aircraft - F-80, F-100, F-105, F-106, etc.

Notice in the examples above that the design numbers for each basic mission are larger as you proceed to the right. The larger design numbers are used for aircraft which were designed at a later date.

Mark the following statements true (T) or false (F).

_____1. An A-4 aircraft is a fighter aircraft.

_____2. A B-47 is a newer design than a B-25 aircraft.

_____3. The letter in "F-105" is the basic mission letter.

_____4. The number in "C-130" is the design number of a cargo/transport aircraft.

Answers to Frame 6: __T__1. __T__2. __T__3.

Frame 8

You have just seen that larger design numbers indicate newer (or later) models of the same type of aircraft. The design numbers have been getting so large, that the government has decided to begin the design numbering sequence all over again. For example, cargo aircraft designed after the C-141 are designated as C-1, C-2, etc. Likewise, the F-111 is the last fighter designation in the series. Newer fighters are designated F-1, F-5, etc. In the case of bombers, the B-70 is the last large numbered bomber. As you may know, the newest bomber design was given the number B-1; and although it is not in the Air Force inventory, its design number, B-1, still stands.

Mark the following statements true (T) or false (F).

_____1. An F-5A is a newer design aircraft than the F-106A.

_____2. An RC-135A was designed before the C-141A.

_____3. The F-105 was designed after the F-4.

Answers to Frame 7: F 1. T 2. T 3. T 4.

Frame 9

A series letter always follows the design number, for example, C-5A, C-5B, etc. Series letter "A" is used for all newly designed aircraft. These aircraft, as a rule, remain series "A" as long as they are used by the Air Force. To understand just how series letters change, let's look at an example.

Let's say the government makes a contract with Boeing to produce 100 B-52 aircraft. As those 100 models roll off the assembly line, they are given the series letter "A" - thus the number of the aircraft becomes B-52A. As the Air Force uses these "A" models, they will find that certain modifications or changes need to be made. The changes are usually made by qualified Air Force personnel, but the series letter of the aircraft remains "A."

Now at some time in the future, the Air Force will make another contract for say 100 more B-52 aircraft. But these new aircraft must contain all the modifications that were made to the first 100. Therefore, since these new aircraft are different in design from the first 100 which Boeing made, they assign them a different series letter - in this case "B" and all 100 of these new aircraft will be given the number B-52B. Each new contract for this B-52 aircraft will generate a new series letter if the design is changed from the last contract. Understand that the series change does not change the function of the aircraft - in our example, the aircraft is still a bomber. A series change only improves that function.

Mark the following statements true (T) or false (F).

_____1. A B-52A aircraft has no major design modifications.

_____2. In the designator KC-135B, the K represents a series change.

_____3. The series letter in the designator WB-66D is "D."

_____4. A C-135B aircraft has had one major modification.

Answers to Frame 8: T 1. T 2. F 3.

Frame 10

Aircraft have serial numbers to make it easier to distinguish between aircraft of the same design, for instance, one KC-135B from another KC-135B. Serial numbers include the two digits that represent the aircraft contract year separated by a hyphen from the rest of the number (75-12345). The component assignment letter, indicating the organization to which the aircraft is assigned, is added as a suffix to the serial number. The component assignment letter "A" is used to identify aircraft assigned to the Air Force (75-12345A). The serial number, symbol, type of fuel, and technical order reference are stenciled on the left side of the fuselage under the pilot's window, as shown below. Remember where to find the aircraft serial number since you will be required to use it when recording your work.

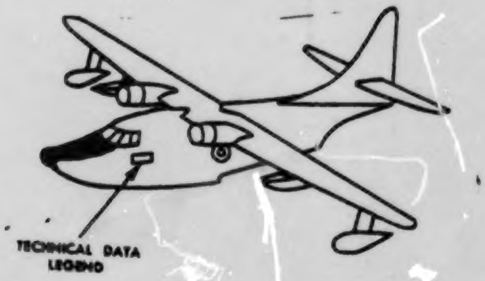


Figure 1.

Mark the following statements true (T) or false (F).

_____1. The suffix symbol "A" in the aircraft serial num[illegible]1762A indicates assignment of the aircraft to the Air For[illegible]

_____2. The serial number of an aircraft is located under the pilot's window on the outside (left side) of the fuselage.

_____3. In the aircraft number 77-12345, the first two digits indicate that the aircraft was purchased in July of 1970.

_____4. Aircraft serial numbers have a maximum of four digits.

Answers to Frame 9: T 1. F 2. T 3. T 4.

Frame 11

The radio call number (tail number) consists of five digits. It is applied to each side of the vertical stabilizer and is derived from the last five digits (12345) of the aircraft serial number (75-12345). When it is necessary to use the contract year, the first digit and the hyphen are not used. Thus, the radio call number for serial number 75-1234 would be 51234. If the serial number has less than five digits, say 77-12, zeros will be added following the second digit of the contract year to make a total of five digits (70012). Duplication of radio call numbers, derived from the serial numbers 65-1234 and 75-1234 is prevented by using the symbol "0-" in front of the earlier year - for example, the radio call number for the 10-year-old aircraft (65-1234) is 0-51234. The call number for the other aircraft is 51234. It is possible that another 20-year-old aircraft with the same call number (55-1234) is on the same base. Although such instances are rare, they do occur and the local command at that base will have its own particular method of identifying such aircraft.

Remember how radio call numbers are derived and where they are located because you will be assigned work by the tail number of the aircraft. In the maintenance shop, this is the easiest form of identification.

Complete the following statements by filling in the appropriate blank on your response sheet.

1. If 65-1576 is the serial number of a 10-year-old aircraft, and a 1975 model aircraft has the same serial number, what would be the radio call number of the 1965 model aircraft? __________

2. The radio call number of a B-52G, serial number 72-0007 would be __________.

3. The radio call number of a C-141, serial number 75-65321 would be __________.

Answers to Frame 10: T 1. T 2. F 3. F 4.

Frame 12

Circle the letter of the correct response to the following statements.

1. The basic mission of an F-104C is to
   a. carry cargo and/or passengers.
   b. intercept and destroy other aircraft.
   c. bomb enemy targets.
   d. search out, attack, and destroy land targets.
2. The basic mission of an RC-47A is to
   a. search out, attack, and destroy land targets.
   b. take pictures on reconnaissance flights.
   c. carry cargo.
   d. tow targets.
3. The modified mission of a TB-58A is
   a. for training personnel.
   b. to bomb enemy targets.
   c. to transport personnel.
   d. to attack enemy land targets.
4. The series letter of an HU-16B is
   a. B.
   b. H.
   c. U.
   d. not shown.

5. A WB-57 designator means that the aircraft is

   a. an attack type used for training.

   b. a weather type used for training.

   c. a fighter modified for training pilots.

   d. a bomber with weather equipment installed.

6. The aircraft serial number is located

   a. inside the pilot's compartment, under the left window.

   b. outside the fuselage, under the pilot's window.

   c. on the lower side of the left wing.

   d. on both sides of the fuselage.

7. One distinguishing characteristic of a cargo/transport aircraft is its

   a. small size.

   b. thin, short wings.

   c. large cargo door.

   d. number of engines.

8. The basic mission of a B-47A is to

   a. carry cargo.

   b. carry passengers.

   c. bomb enemy targets.

   d. intercept and destroy enemy aircraft.

Answers to Frame 11: 1, 0-51576 2. 20007 3. 65321

Frame 13

You have completed the first part of this lesson covering the types, designation and distinguishing characteristics of military aircraft. The next section deals with the major structural components of an aircraft—the fuselage, wings, empennage, engine nacelles, jet pods, and some more aircraft markings.

NO RESPONSE REQUIRED

Answers to Frame 12: 1. b 2. c 3. a 4. a 5. d 6. b 7. c
8. c

Frame 14

The fuselage is the central body portion of an aircraft. The cabin or cockpit is located in the nose of the fuselage and is sometimes referred to as the crew compartment.

The central portion of the fuselage is the cargo or passenger section of cargo/transport aircraft. The central portion of a bomber fuselage is used to carry bombs. Fuel is sometimes carried in this section of refueling (tanker) aircraft.

An illustration of the KC-135A "tanker" is shown below. This aircraft has large tanks of jet fuel in its fuselage which is used to refuel other aircraft in flight. The national star insignia (A) and U.S. Air Force (B) are markings on each side of the fuselage and are located on most aircraft in approximately the same position as shown.

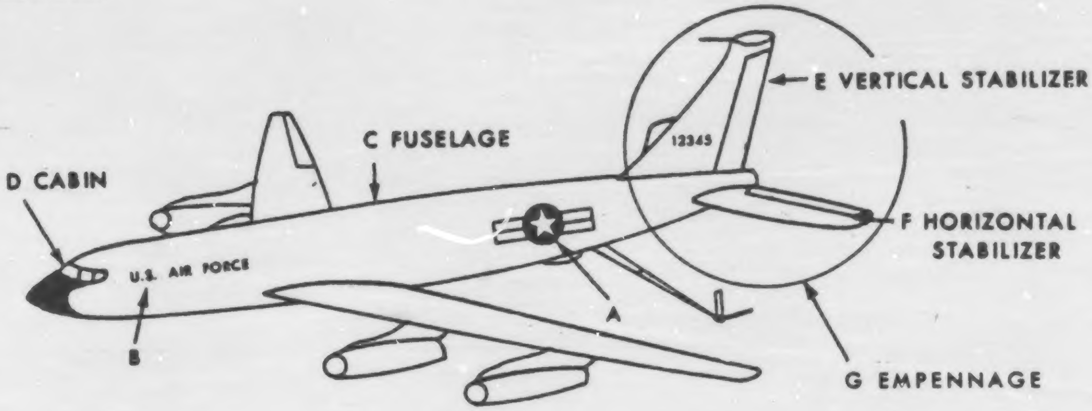


Figure 2.

Mark the following statements true (T) or false (F).

_____1. The fuselage is represented by section "C" in the above illustration.

_____2. Fuel is carried in the section labeled "D."

_____3. The cabin area is located in the nose of a KC-135.

_____4. Markings "A" and "B" are found on both sides of the fuselage.

_____5. The empennage is the tail section of an aircraft.

Answers to Frame 13: No response required

Frame 15

All aircraft have wings (airfoils) to provide lift and support the aircraft in flight. High speed jet fighters, such as the F-104A, have short thin wings as shown in illustration A. The WU-2A, shown in B below, has long thin wings to support flight at extremely high altitude where the air is thin. A helicopter, C, has rotary wings which enable it to fly vertically and horizontally. Cargo aircraft have thick, long wings to provide more lift.

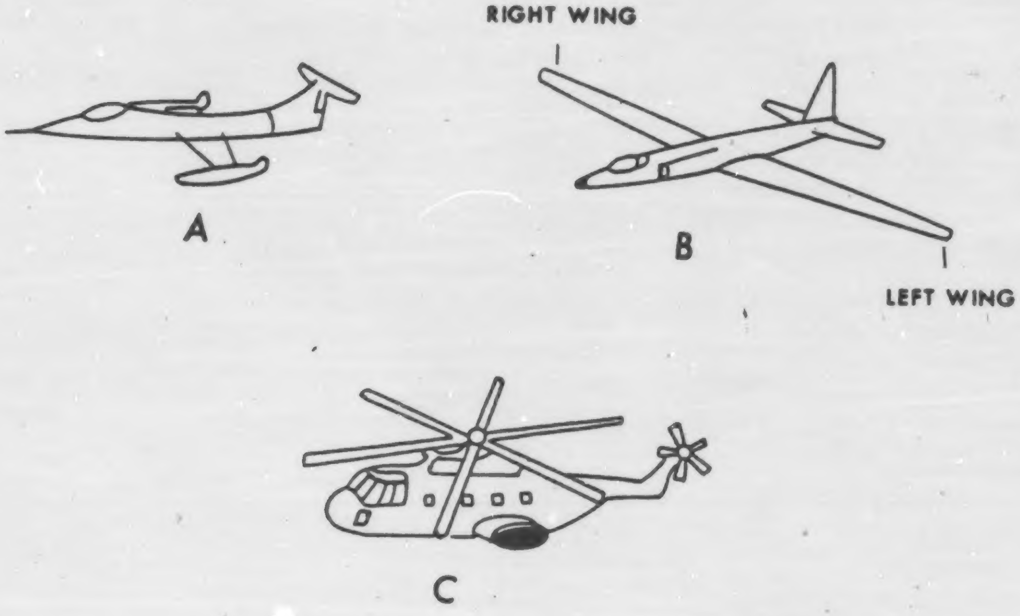


Figure 3.

Is the following statement true? Circle either YES or NO.

1. Wings are structural units that support the aircraft in flight by providing lift.

YES NO

Answers to Frame 14: __T__ 1. __F__ 2. __T__ 3. __T__ 4. __T__ 5.

Frame 16

Aircraft reciprocating engines (engines with pistons) are enclosed in engine nacelles. The nacelles cover, streamline, and help cool the engines.

Jet pods cover and streamline jet engines when the engines are mounted under the wings.

Engines are numbered one, two, three, four, etc., starting at the aircraft's left wing tip as seen when you are sitting in the cockpit looking forward.

Mark the following statements true (T) or false (F).

_____1. Aircraft engines are numbered from right wing tip to left wing tip.

_____2. An aircraft has the same number of nacelles or pods as it has engines.

_____3. Nacelles cover, streamline, and help cool reciprocating engines.

Answer to Frame 15: YES

Frame 17

Match the numbers of the illustration below to location of markings and the part of the aircraft they identify. Write the correct number in the appropriate spaces provided.

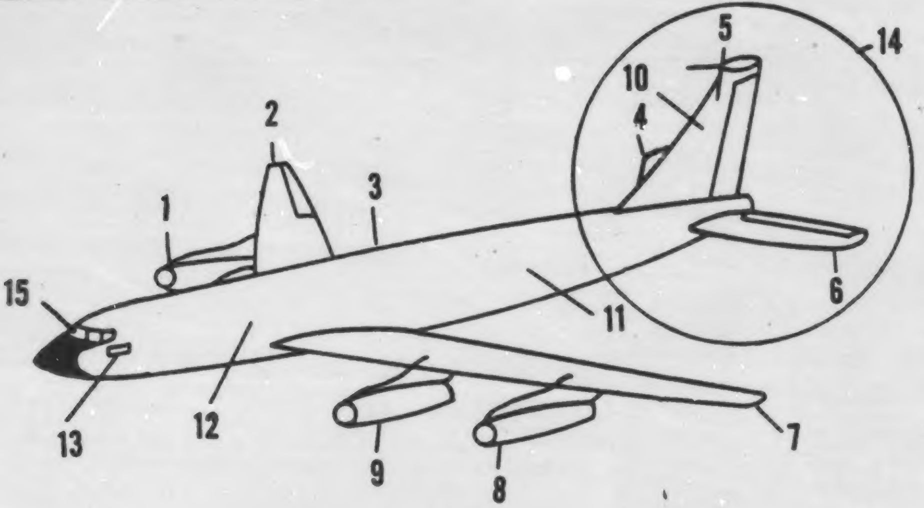


Figure 4.

_____a. Vertical stabilizer

_____b. Number 2 engine

_____c. Right wing

_____d. Right horizontal stabilizer

_____e. Left horizontal stabilizer

_____f. Number 4 engine

_____g. Fuselage

_____h. Left wing

_____i. Call number

_____j. U.S. Air Force

_____k. Technical data legend

_____l. National star (fuselage)

_____m. Number 1 engine

_____n. Empennage

_____o. Cabin

Answers to Frame 16: F 1. T 2. T 3.

Frame 18

THE GENERATION OF LIFT

A balloon filled with hydrogen or helium rises because the weight of the air it displaces is greater than the weight of the balloon. The amount of force that keeps it up in the air is the difference between the balloon's weight and the weight of the air (see figure 5). Another way of saying this is that the balloon's lift factor is greater than the balloon's weight (which is the pull of gravity on the balloon - see figure 6).

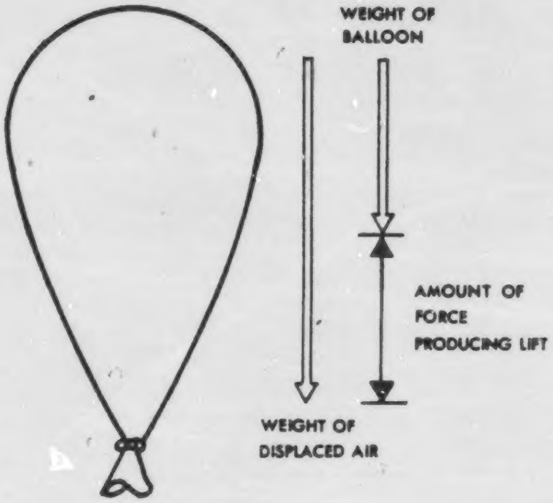

WEIGHT OF BALLOON
AMOUNT OF FORCE PRODUCING LIFT
WEIGHT OF DISPLACED AIR

Figure 5.

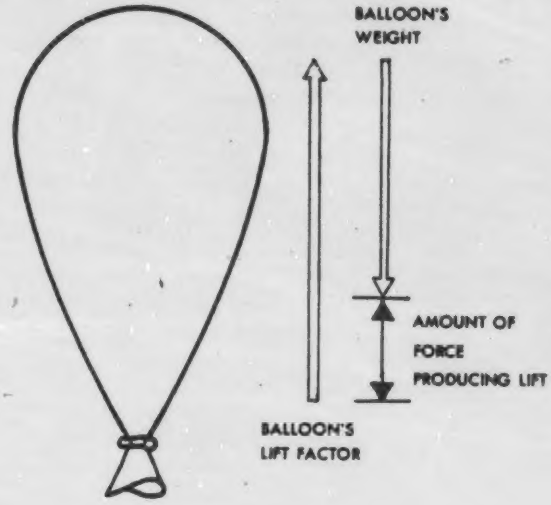

BALLOON'S WEIGHT
AMOUNT OF FORCE PRODUCING LIFT
BALLOON'S LIFT FACTOR

Figure 6.

NO RESPONSE REQUIRED

133

Answers to Frame 17: 5 a. 9 b. 2 c. 4 d. 6 e.
1 f. 3 g. 7 h. 10 i. 12 j.
13 k. 11 l. 8 m. 14 n. 15 o.

Frame 19

An aircraft gets lift from the air through which it flies, but in a different way from a balloon. Since the aircraft weight is greater than the weight of air it displaces, it cannot rise like a balloon. It must generate its own lift by moving through the air at high speed and allowing the wings to lift the aircraft.

There are four major forces acting on an aircraft while it is flying. One of these forces is already known to you. This force is called gravity. The force which makes the aircraft move forward through the air is called thrust. Keep in mind that without thrust, lift cannot be generated. But, as thrust moves the aircraft through the air, another force is produced. This force is known as drag - anything that moves through the air causes drag. These four forces are summarized in the diagram below and explained in greater detail in the following frames. Only when you become familiar with the action of these forces on the aircraft in flight can you understand how aircraft can be controlled in the air.

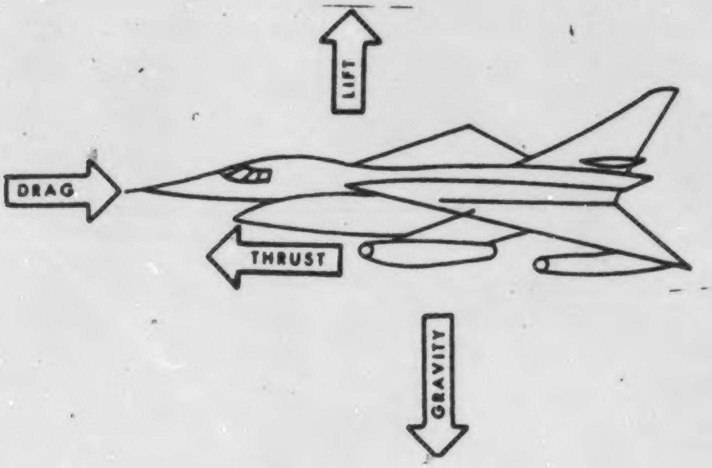


Figure 7.

Circle the correct letter.

1. The force necessary to create lift is

   a. thrust.

   b. torque.

   c. weight.

   d. drag.

155

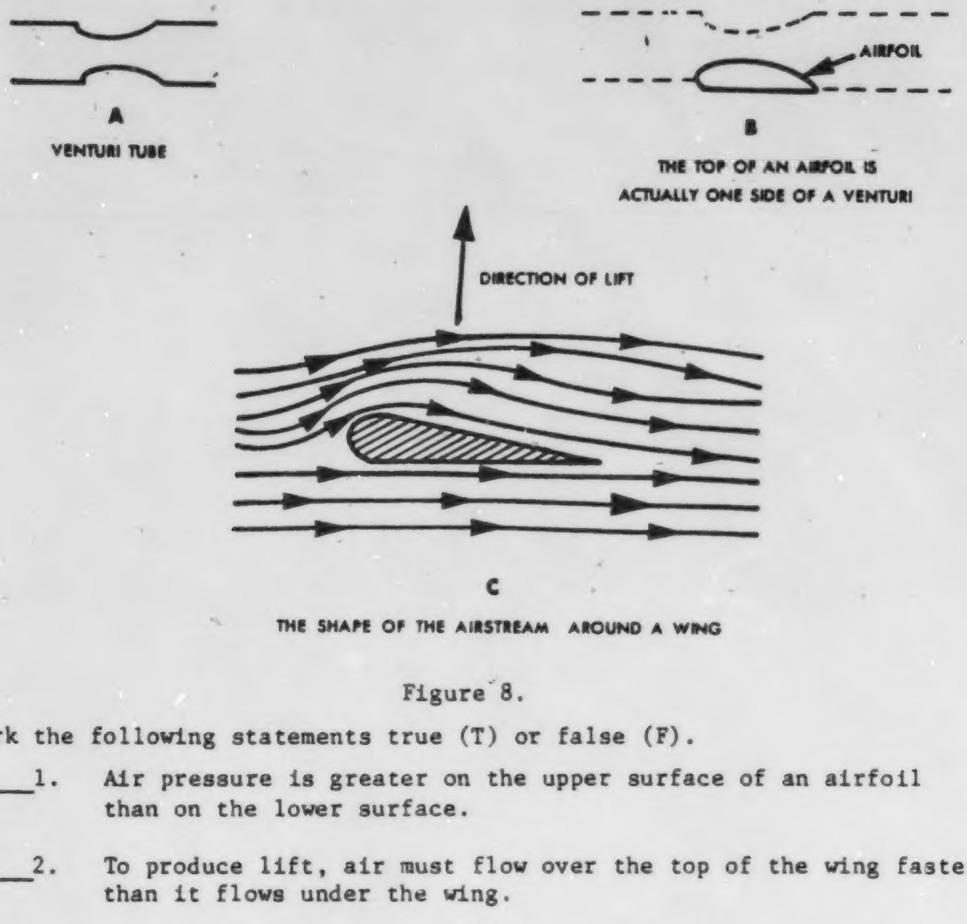
Answers to Frame 18: No response required

Frame 20

The force that overcomes gravity and holds the aircraft up during flight is called lift. An aircraft gets its lift from the air which passes over and under the wings as a result of its motion. To understand how a wing generates lift, let's first examine a very important discovery made by a man named Bernoulli.

Bernoulli forced air through a piece of tubing that had a slight reduction in it called a venturi (see diagram "a" below) and measured the velocity and pressure of the airstream at various places inside the tube. He noted that the velocity of the air increased as it went into the venturi. He also noticed that as the velocity increased, the air pressure decreased.

Since a wing (also called an airfoil) is shaped like a venturi (see diagram "b"), the airstream flowing over the top of the wing will travel faster than the air under the wing. Thus, by Bernoulli's principle, the pressure of the air will be lower on the top of the wing and higher on the bottom. Therefore, as the aircraft moves through the air, its airfoils all help to generate the lift needed to support the aircraft in flight (see diagram "c").



A
VENTURI TUBE

B
THE TOP OF AN AIRFOIL IS ACTUALLY ONE SIDE OF A VENTURI

C
THE SHAPE OF THE AIRSTREAM AROUND A WING

Figure 8.

Mark the following statements true (T) or false (F).

_____1. Air pressure is greater on the upper surface of an airfoil than on the lower surface.

_____2. To produce lift, air must flow over the top of the wing faster than it flows under the wing.

Answer to Frame 19: 1. a

Frame 21

Since the air pressure on the wing decreases as the velocity of the airstream over the wing increases, it is easy to see that the faster the aircraft moves through the air, the more lift its wings will generate. Therefore, lift is affected by airspeed (the speed at which air flows around the wings).

Lift is also affected by something known as angle-of-attack. Angle-of-attack can be simply defined as the angle at which the wing meets the airflow. But this definition, although simple, doesn't explain the meaning exactly. To explain angle-of-attack properly, first you need to know the meaning of chord and relative wind.

The chord (pronounced like cord) of a wing is shortest distance from the trailing edge to the leading edge of the wing (see figure 9).

In aerodynamics, the relative wind is always directly opposite to the flight path of the aircraft. Flight depends entirely upon maintaining sufficient airflow over the wings. This is why aircraft always take off into the wind.

Figure 9 below shows an airfoil and its chord line extending from the leading edge to the trailing edge. Also shown is the direction of the relative wind (coming from the left in the diagram). The angle-of-attack is labeled α (pronounced alpha) in the diagram.

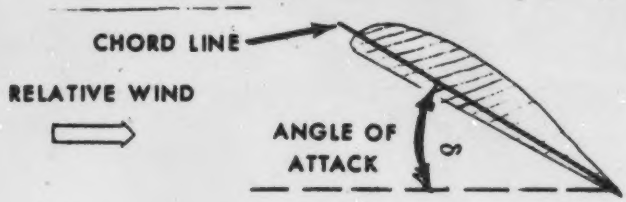


Figure 9.

It is possible that the angle-of-attack can become so great that the airfoil stops generating lift. When this occurs, it is referred to as stall and the angle-of-attack at which stall occurs is called the stall angle. Do not spend time memorizing these terms now. They have been introduced to you so that you will recognize and be able to use them when you see them again later in the course. You should keep in mind though that both airspeed and angle-of-attack are factors that affect lift.

NO RESPONSE REQUIRED

Ansewrs to Frame 20: F 1. T 2.

Frame 22

The one force with which we are most familiar is gravity. It is the force which attracts bodies toward the center of the earth. Gravity is always at work trying to keep the aircraft on the ground or to pull it back to the ground once it is in the air.

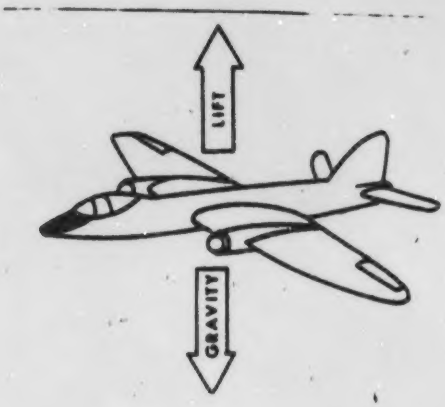


Figure 10.

Is this statement true or false? Circle either YES or NO.

1. The force which opposes gravity is lift.

YES NO

137

Answers to Frame 21: No response required.

Frame 23

In order for the aircraft to get the motion required for lift, another force is required. This force is called thrust. The thrust may come from the propeller driven by a reciprocating engine or a turbo-prop engine, or from the reaction of exhaust gases in a jet engine. In general, the larger the aircraft the greater the thrust required to lift it off the ground.

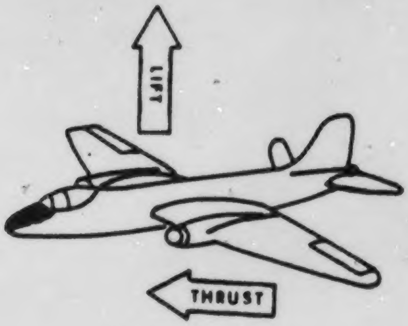


Figure 11.

Circle the correct letter.

1. The force required for lift is

   a. drag.

   b. gravity.

   c. thrust.

   d. torque.

159

Answer to Frame 22: 1. YES

Frame 24

As soon as the aircraft starts moving to create lift, another force is created which opposes the movement (see illustration below). This force is called drag. Part of the drag is caused by the wing and is called induced drag, because it is produced as a result of the creation of lift. Part of the drag is caused by the fuselage and other parts of the aircraft exposed to the airstream and is called parasitic drag. There is no way of preventing drag, but by proper design it can be kept to a minimum. Drag always acts at right angles to lift and opposite in direction to thrust.

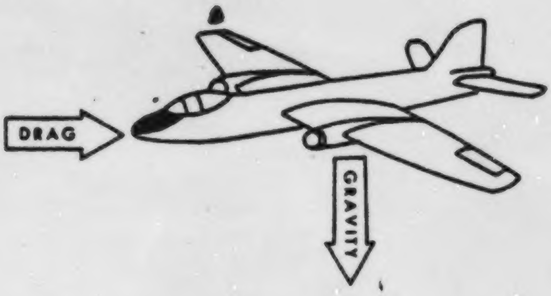


Figure 12.

Circle the correct letter.

1. The type of drag caused by the wing is called

   a. parasitic drag.

   b. induced drag.

   c. residual drag.

   d. reduced drag.

139

Answers to Frame 23: 1. c

Frame 25

All bodies that turn, move around (about) a line called an axis. There are three imaginary axes about which an aircraft can turn. These axes are imaginary straight lines passing through the center of gravity of the aircraft. The center of gravity of an aircraft is the point from which it can be suspended in air and remain at a level position.

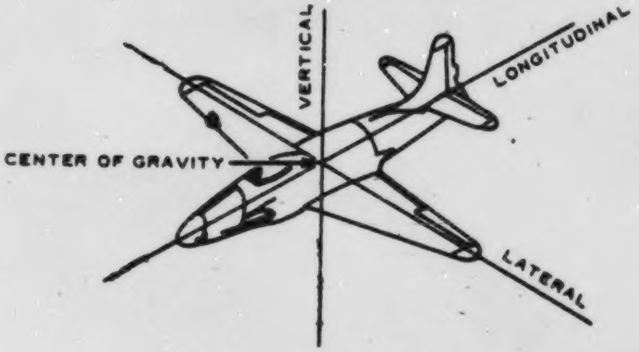


Figure 13.

Circle the correct letter.

1. Center of gravity of an aircraft is an imaginary
   a. line through the longitudinal center of the aircraft.
   b. point at which, if suspended, the aircraft remains in a level position.
   c. line bisecting the vertical centerline of the aircraft.
   d. line from wing tip to wing tip.

161

Answer to Frame 24: 1. b

Frame 26

The longitudinal axis extends from the nose of the aircraft to the tail, through the center of gravity. Movement about (around) this axis is called roll or bank.

The axis which extends from wing tip to wing tip, through the center of gravity is called the lateral axis. Movement about (around) this axis is called pitch (climbing or diving).

The imaginary vertical line passing through the center of gravity is called the vertical axis. Movement around (about) this axis is called yaw.

On the diagram below, select the letter which identifies each axis of the aircraft and write the letter in the appropriate space.

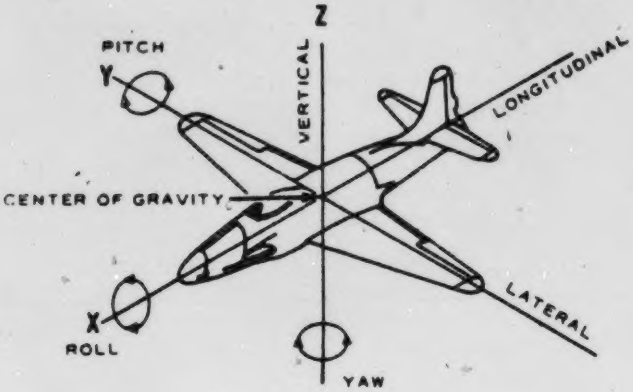


Figure 14.

_____a. Lateral axis

_____b. Vertical axis

_____c. Longitudinal axis

_____d. Roll axis

_____e. Yaw axis

_____f. Pitch axis

Answers to Frame 25: 1. b

Frame 27

In a previous frame, you learned how an aircraft wing (airfoil) generates lift when air flows around it. Now let's say that the wing has a movable surface attached to its trailing edge by a hinge and is capable of moving up or down. We call this movable surface a control surface because it can control the movement of the aircraft. Before discussing what happens when the control surface is moved up or down into the airstream, you must first become familiar with some terms that you will use virtually every day in your Air Force career.

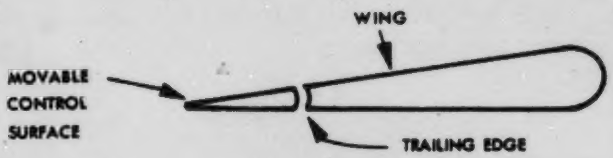


Figure 15.

In the illustration above, the control surface is aligned with the wing and is said to be streamlined. In other words, it is not deflected into the airstream. If the control surface is attached to the wing of the aircraft, the control surface is called an aileron; if it is attached to the rear horizontal stabilizer, the control surface is called an elevator; and if the control surface is attached to the tail (or vertical stabilizer), the control surface is called a rudder. See the aircraft control surface trainer in the front of the reading room.

The ailerons, elevators, and rudder are known as primary flight controls. The ailerons and elevators are connected by means of cables or push rods to the control column or control stick in the cockpit so they can be operated by the pilot and co-pilot. The rudder is connected to, and controlled by, the rudder pedals in the cockpit. Each control surface controls the aircraft's movement about one of three axes (lateral, longitudinal, or vertical) while the plane is in flight.

Check the correct response to the following statements.

1. The hinged surfaces, or controls, which control the directional movement about the axes of the aircraft are called

_____a. secondary flight controls.

_____b. auxiliary flight controls.

_____c. primary flight controls.

_____d. accessory flight controls.

2. Primary flight controls consist of

_____a. flaps, rudder, and stabilizer.

_____b. rudder, ailerons, and elevators.

_____c. spoilers, tabs, and flaps.

_____d. rudder, tabs, and ailerons.

Answers to Frame 26: Y a. Z b. X c. X d. Z e. Y f.

Frame 28

You have just learned that if the control surface is not deflected up or down, then it is said to be streamlined with the wing. Actually, the wing and the control surface appear to the relative wind like a single wing. In other words, when the control surface is streamlined, the relative wind flows passed the wing and generates lift due to the shape of the wing as you have already learned.

If, however, the control surface is moved up or down, the relative wind acts on the wing as if the entire wing has changed shape! Let's see what happens when the control surface is moved down into the airstream.

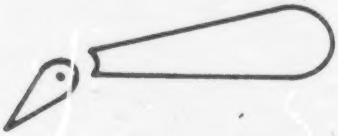


Figure 16.

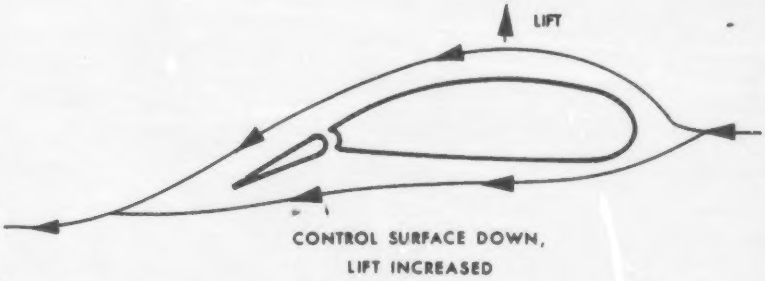


Figure 17.

Figure 16, above, shows the control surface deflected down; while figure 17 shows how the relative wind "sees" the wing in this configuration. Notice the airflow lines over and under the wing in figure 17. With the control surface deflected down, the top of the wing actually appears to be curved more now than it was when the wing was streamlined. Recall that the curve (or venturi shape) of the top of the wing is what causes the lower pressure on top and thus produce an upward lift. Well, since the wing now has more curve on top (see figure 17), its lift factor will increase. In short, when the control surface is moved down, lift is increased.

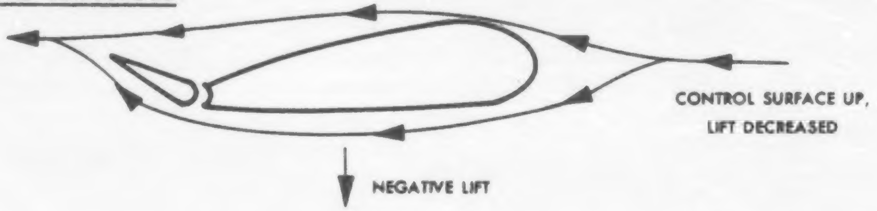


Figure 18.

In figure 18 above, the control surface is moved up into the airstream. In this configuration, the relative wind acts on the wing as if the underside of the wing were more curved than the top. This produces the opposite lift effect from before. The wing still produces lift, but this time the lifting force causes the wing to go down. This is sometimes called negative lift. It would be just as correct to say that when the control surface is moved up, lift is decreased.

Frame 28 (Cont'd)

Mark the following statements true (T) or false (F).

_____1. When the control surface is moved up, the wing loses lift.

_____2. When the control surface is moved down, the wing loses lift.

_____3. If the control surface is streamlined, the wing generates no lift.

_____4. If the top of the wing is more curved than the bottom, lift is produced in an upward direction.

_____5. When the control surface is moved up, the underside of the wing will appear to have more curve to it than the top, thus negative lift is produced in a downward direction.

Answers to Frame 27: 1. c 2. b

Frame 29

The elevators cause the aircraft to move around the lateral (pitch) axis. They are connected by hinges to the horizontal stabilizer so that the pilot can move them up or down by moving the control column (or stick) forward or backward.

If the stick is pulled backward, both elevators move up. As you learned earlier, this causes the horizontal stabilizer to lose lift. Thus the tail of the aircraft drops causing the nose of the plane to pitch up.

If the control stick is pushed forward, the elevators move down. This produces more lift in the tail section of the aircraft causing it to go up and the nose of the plane to pitch down. Remember, stick back - nose up; stick forward - nose down. To see the elevators in action, refer to the aircraft control surface trainer in the classroom and ask your instructor to demonstrate it.

TRUE or FALSE

_____1. The elevators move in opposition to each other - when the left goes up, the right goes down and vice versa.

_____2. Elevator's control the pitching of the aircraft.

_____3. If the pilot pushes the stick forward, the plane will go into a dive.

Answers to Frame 28: T 1. F 2. F 3. T 4. T 5.

Frame 30

The rudder is connected to the rudder pedals inside the cockpit. There is a left and right rudder pedal that move opposite each other. That is, when the right rudder pedal is depressed, the left rudder pedal pushes up causing the cable connections to move the rudder to the right. Air pressure on the rudder then pushes the tail to the left and the aircraft pivots around the vertical axis so that its nose moves to the right. In short, right rudder pedal depressed causes the nose of the aircraft to move to the right. In a similar manner, depressing the left rudder pedal causes the nose of the plane to move to the left. This movement about the vertical axis is called yaw. See the aircraft control surface trainer.

Check the letter of the correct responses to the following statements.

1. Movement about the vertical axis is called

_____a. roll.

_____b. yaw.

_____c. pitch.

_____d. drag.

2. The rudder causes the aircraft to move around (about) which axis?

_____a. Longitudinal

_____b. Lateral

_____c. Horizontal

_____d. Vertical

3. The primary flight control which is hinged to the trailing edge of the vertical stabilizer is the

_____a. aileron.

_____b. elevator.

_____c. rudder.

Answers to Frame 29: F 1. T 2. T 3.

Frame 31

The ailerons control the movement of the aircraft around the longitudinal (roll) axis. They form a part of the trailing edge of the wings, but they are hinged in place so that they can be moved up or down. Each wing has an aileron.

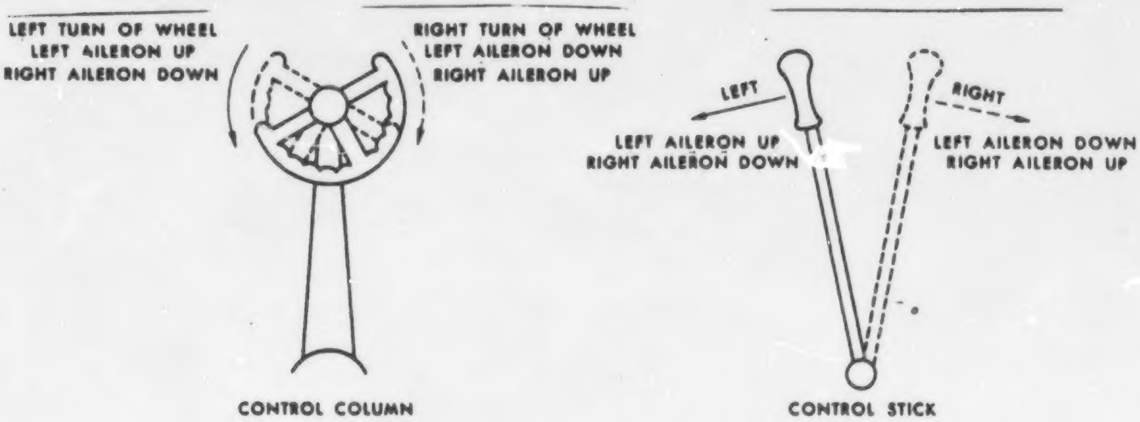

LEFT TURN OF WHEEL
LEFT AILERON UP
RIGHT AILERON DOWN
RIGHT TURN OF WHEEL
LEFT AILERON DOWN
RIGHT AILERON UP
CONTROL COLUMN
LEFT
RIGHT
LEFT AILERON UP
RIGHT AILERON DOWN
LEFT AILERON DOWN
RIGHT AILERON UP
CONTROL STICK

Figure 19.

The ailerons are connected to the control system so the pilot can move them by turning the control column wheel to the right or left, or by pushing the control stick from side to side as illustrated above. The ailerons are rigged so that when one aileron is raised, the other one is lowered. As shown in the illustration, when the control column wheel is turned to the left or the control stick is pushed to the left, the left aileron moves up and the right aileron moves down. This movement has the effect of increasing the lift of the wing with the lowered aileron and decreasing the lift of the wing with the raised aileron. If the control column wheel or stick is moved to the right, the action of the ailerons reverses. To better understand the operation of the ailerons, refer to the aircraft control surface trainer in the reading room.

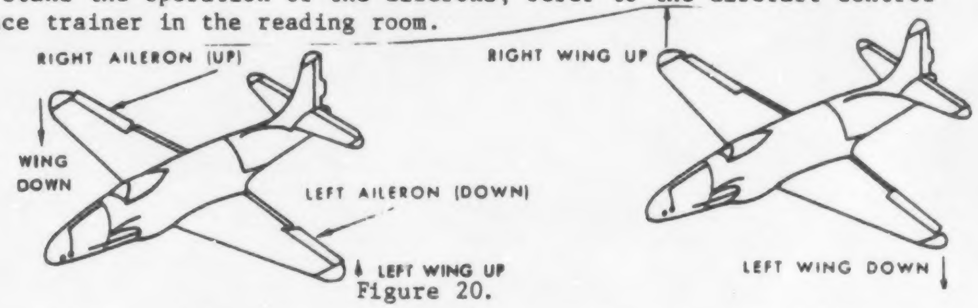

RIGHT AILERON (UP)
WING DOWN
LEFT AILERON (DOWN)
LEFT WING UP
RIGHT WING UP
LEFT WING DOWN

Figure 20.

Using the diagram above, check the correct statement as true (T) or false (F).

_____1. The ailerons cause the plane to roll about the longitudinal axis.

_____2. Aircraft movement caused by the ailerons is called yaw.

_____3. The ailerons move in the same direction at the same time.

Answers to Frame 30: __b__ 1. __d__ 2. __c__ 3.

Frame 32

Match the information given in the right-hand column below to the appropriate flight control listed in the left-hand column. Write the correct letter in the appropriate spaces provided.

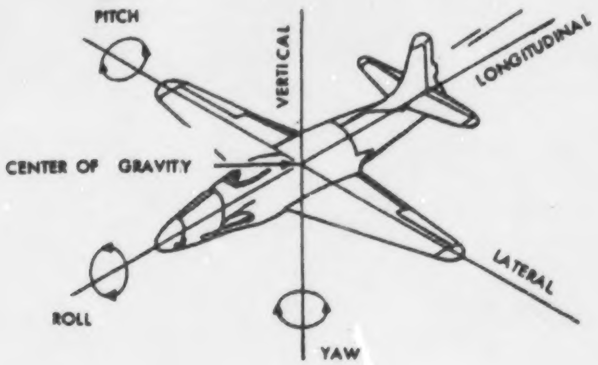

PITCH
VERTICAL
LONGITUDINAL
CENTER OF GRAVITY
LATERAL
ROLL
YAW

Figure 21.

a. Ailerons

b. Elevators

_____1. Locatdd on the trailing edge of the horizontal stabilizer.

_____2. Cause movement about the longitudinal axis.

_____3. Located on the trailing edge of both wings.

_____4. Controls roll or bank.

_____5. Cause movement about the lateral axis.

Answers to Frame 31: T 1. F 2. F 3.

Frame 33

HOW AN AIRCRAFT TURNS

Most of you are familiar with riding two-wheel bicycles. Have you ever thought about how you turn corners on a bicycle? When approaching a right or left turn, the basic maneuver is to lean in the direction of the turn. The action of tilting the bicycle left or right causes the cycle to turn the corner. If you were to sit straight up on the cycle and only turn the handle bars, you would have to make a very gradual turn in order to keep your balance and remain stable in the turn. However, by tilting the cycle and leaning into the turn, you can make sharper turns at higher speeds and still remain stable. Truly, the most efficient means of turning corners on a bicycle is to tilt the cycle in the direction of the turn.

Believe it or not, an aircraft is very similar to a bicycle in the way it turns in the air. Contrary to what many people think, the rudder on the aircraft is not used to execute turn maneuvers. In order to turn to the left or right, the pilot banks or rolls the aircraft in the direction he wishes to turn with the use of the ailerons. The greater the bank angle, the sharper the turn will be. However, there is a limit to how steep the bank angle may be depending on how fast the aircraft is traveling. If the aircraft is traveling too fast, it will skid out of the turn. If the plane is traveling too slowly for the particular bank angle set by the pilot, it may slip (or fall) into the turn.

Both slipping and skidding are considered uncoordinated turn conditions. If a turn becomes uncoordinated, the rudder is used to recoordinate the turn. This is one primary use for the rudder in flight. You will learn other uses for the rudder in a later block. For now, it is important to remember that

1. the ailerons are used to turn by causing the aircraft to bank to the left or right.

2. the rudder is used for turn coordination if the aircraft slips or skids during the turn.

NO RESPONSE REQUIRED

Answers to Frame 32: b 1. a 2. a 3. a 4. b 5.

Frame 34

According to Newton's First Law of Motion, a body already in motion will remain in motion in the same direction until it is acted upon by an unbalanced force. You know from a previous frame that in straight and level flight, all the forces acting on the plane are in balance. Therefore, the plane will continue flying straight and level. If the pilot pulls the control stick to the right, the ailerons repositio themselves out of their streamlined position creating unbalancing forces on the plane causing it to roll to the right. This, as you now know, causes the plane to turn to the right.

Now let's say the pilot places his control stick back to center. This of course will cause the ailerons to become streamlined once again. All the forces become balanced on the aircraft again and the plane obeys Newton's first law - it remains banked to the right and will continue turning to the right. In fact, the plane will turn circles in the air until the pilot pushes his control stick to the left to bring the plane out of the turn.

What has been said above is true not only for ailerons, but also for elevators and rudder. When the pilot performs a maneuver with the control surfaces, the aircraft will react. Once the aircraft has reached its new position, the pilot must re-streamline the control surface. The plane will then continue flying in that new position until the pilot (or autopilot) commands a different maneuver.

NO RESPONSE REQUIRED

Answers to Frame 33: No response required

Frame 35

The secondary control surfaces are the trim tabs, balance tabs, and servo tabs. These tabs are used to reduce the force required to move the primary control surfaces and for trimming and balancing the aircraft while in flight. These tabs are small airfoils attached to, or recessed into, the trailing edge of the primary control surfaces.

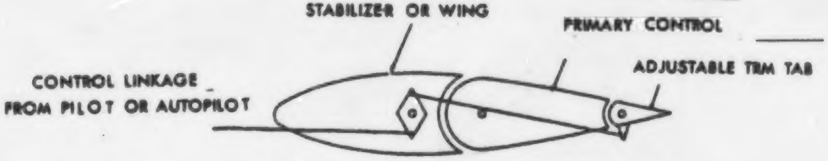

STABILIZER OR WING
PRIMARY CONTROL
ADJUSTABLE TRIM TAB
CONTROL LINKAGE
FROM PILOT OR AUTOPILOT

Figure 22.

In the illustration above, an adjustable tab is attached to the primary control surface. When the pilot or autopilot operates the control linkage, the tab moves first which creates enough air pressure difference to cause the primary control surface to move in the opposite direction.

In the illustration below, notice that the down moving tab caused the primary control surface to move up.

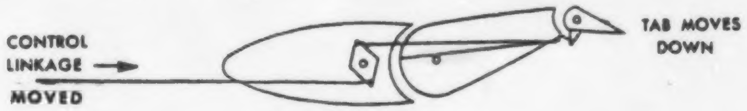

CONTROL
LINKAGE
MOVED
TAB MOVES
DOWN

Figure 23.

Such tabs are not generally required on modern aircraft, however, due to the use of hydraulic power to give the pilot mechanical advantage. But there is another type of secondary control surface that is required on today's fast moving aircraft. They are called spoilers and they operate quite differently from the tabs just discussed.

NO RESPONSE REQUIRED

Answers to Frame 34: No response required

Frame 36

The development of sweptback wings made lateral control by ailerons alone more difficult. Segmented sections called spoilers were attached to the upper surface of the wings for two primary reasons. One reason is to reduce wing twisting caused by the use of ailerons; the second reason is to aid in lateral control of the aircraft.

Actually, spoilers do exactly what their name implies - they spoil or interrupt the flow of air over the wing causing not only a reduction in lift, but also an increase in drag on the affected portion of the wing. When a spoiler is operated on one wing, that wing loses lift and the aircraft rolls in that direction. By activating the spoilers on both wings simultaneously, the spoilers can be used as brakes to reduce airspeed prior to landing and during landing maneuvers.

It is important to remember that although the spoilers perform the same job as ailerons, they do not operate in the same way. Spoilers on the left and right wings can be operated independently from each other. Also, spoilers can only be deflected up into the airstream, never down. Therefore, spoilers can only cause an affected wing to lose lift, not to increase it. The illustration below shows the placement of the spoilers on a large sweptback wing aircraft.

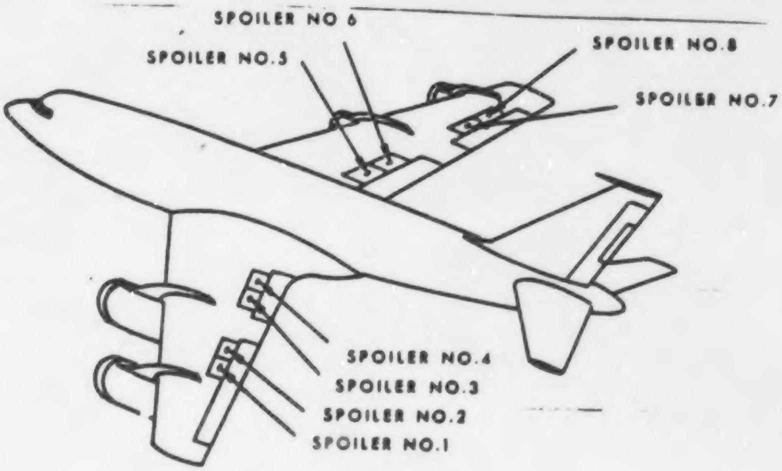


Figure 24.

Select the correct answer.

1. The purpose of spoilers is to
   - a. increase drag during takeoff.
   - b. increase thrust while landing.
   - c. aid in reversing thrust.
   - d. aid in lateral control.

Answer to Frame 35: No response required

Frame 37

The size and speed of aircraft have increased so much that the primary and secondary controls alone are not sufficient for proper control of the aircraft. To supplement these controls, additional control surfaces, called auxiliary flight controls, are used.

As the cruising and top speed of aircraft increased, the landing and takeoff speed also increased. Even though runways were increased in length, it became necessary to find some means for slowing the aircraft without stalling during landing and takeoff.

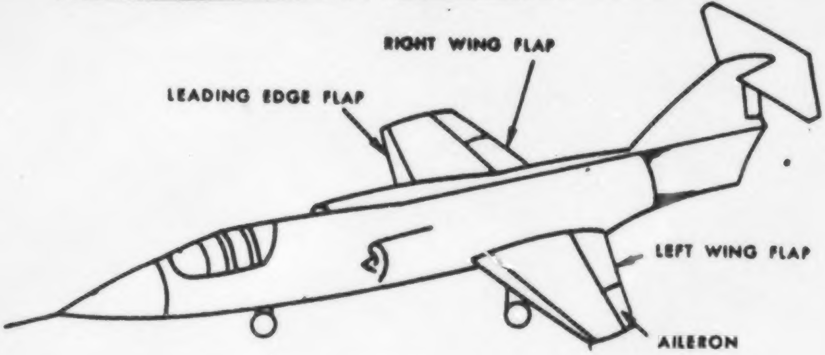


Figure 25.

Flaps of various types were added to increase lift during takeoff and drag during landing. These wing flaps are located on the inboard trailing edge of the wings. On some of our aircraft, such as the F-104 and the F-4C, there are flaps on the leading edge of the wings also.

Select the correct statement.

1. The auxiliary flight control which is used to increase drag on landing and lift during takeoff is the

   a. aileron.

   b. rudder.

   c. wing flap.

   d. elevator.

Answer to Frame 36: 1. d

Frame 38

On some types of aircraft you may see in your Air Force career, the primary and secondary control surfaces are combined and given names which indicate the combination. For example, elevators and ailerons are combined into one control surface called an elevon, rudder and elevator are combined to form a ruddevator; and so on. These, so called, composite control surfaces are not really important in your study right now so we'll leave them and move on to something new.

NO RESPONSE REQUIRED

Answer to Frame 37: 1. c

Frame 39

Place the correct letter in the space next to the circled numbers on the illustration.

a. horizontal stabilizer

b. rudder, controls yaw

c. vertical stabilizer

d. trim tab (rudder)

e. elevator, controls pitch

f. trim tab (aileron)

g. wing flap

h. aileron, controls roll

i. wing (left)

j. spoilers

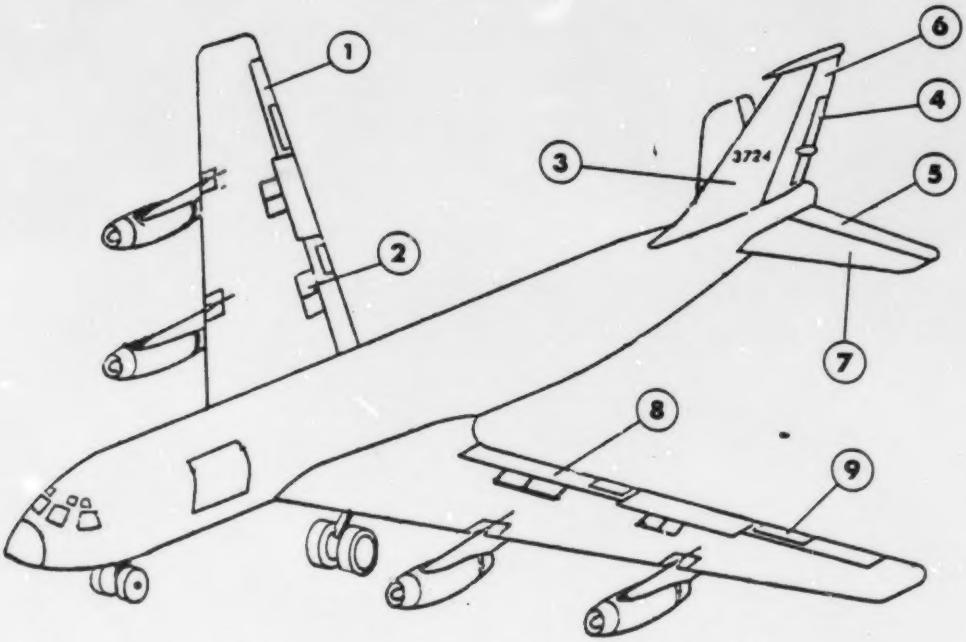


Figure 26.

Answers to Frame 38: No response required

Frame 40

This completes the segment of this lesson principles of flight and flight control surfaces. In this next portion of this text, you will cover major aircraft systems--fuel, oil, propulsion (engine), electrical, hydraulic and landing gear. These systems must be operational if a powered aircraft is to make sustained flight.

The fuel system must provide storage space for large quantities of fuel and supply fuel to the engine at the correct pressure. Without fuel or a fuel system, the propulsion system (engines) is not going to operate.

Mark the following statements true (T) or false (F).

_____1. The fuel system provides the storage space and fuel to operate the engines.

_____2. A powered aircraft can make a sustained (continuous) flight without fuel or a fuel system.

Answers to Frame 39: 1. h 2. j 3. c 4. d 5. e 6. b
7. a 8. g 9. f 10. i

Frame 41

Oil under pressure lubricates the moving parts of an engine. Lubrication of the moving parts prevents them from sticking together (freezing up). Oil does this by reducing friction and the buildup of excessive heat between moving parts. Without oil, an aircraft engine will "freeze up" due to friction and excessive heat. Naturally, the engine's internal parts will be seriously damaged if operated without oil.

Mark the following statements true (T) or false (F).

_____1. The oil system provides lubrication for the moving parts of engines.

_____2. Friction and heat is reduced by the circulating oil.

_____3. Operating an aircraft engine without oil for a short period of time will have no effect on the engine.

Answers to Frame 40: __T__ 1. __F__ 2.

Frame 42

The propulsion (engines) system provides power (thrust) to get the aircraft moving and keep it airborne. It also drives engine accessories for production of electrical, hydraulic and pneumatic power. The two types of engines most commonly used on today's aircraft are the reciprocating (piston) and the jet engine.

Mark the following statements true (T) or false (F).

_____1. The two types of propulsion systems most commonly used on today's aircraft are reciprocating and piston.

_____2. Accessories for producing electrical, hydraulic and pneumatic power are driven by the engine.

_____3. The propulsion system provides the power to get the aircraft airborne.

Answers to Frame 41: T 1. T 2. F 3.

Frame 43

The electrical system provides the electrical energy for igniting the fuel-air mixture in the engine. The electrical system must also furnish current for aircraft lighting and operation of various gages and motors. Modern aircraft are equipped with many electronic devices requiring both alternating current (AC) and direct current (DC) power. The electrical generating components may be driven from the engine's accessory gear case.

Mark the following statements true (T) or false (F).

_____1. Electrical energy is used to ignite the fuel-air mixture in the engine.

_____2. Modern aircraft with many electronic devices require only AC power.

_____3. Engine driven accessories may include electrical generating components.

159

Answers to Frame 42: __F__1. __T__2. __T__3.

Frame 44

The hydraulic system is used to operate flight controls and landing gear on some aircraft. A small force exerted by the pilot is multiplied by this system and transmitted through fluid to units to be operated. Some of the important functions of the hydraulic system is to provide power for raising and lowering the landing gear and operation of the brakes.

Mark the following statements true (T) or false (F).

_____1. The hydraulic system is used to operate and control engine driven accessories.

_____2. A small force exerted by the pilot will be multiplied by the hydraulic system to move a large control surface.

_____3. Before landing, the landing gear is extended by hydraulic system pressure.

181

Answers to Frame 43: _T_ 1. _F_ 2. _T_ 3.

Frame 45

The landing gear system supports the aircraft during landing or while resting on the ground. The landing gear is either fixed or retractable. We are concerned here with the retractable landing gear. There are three types of retractable landing gears; the conventional, tricycle and bicycle. The conventional type has two main wheels and a tail wheel. The tricycle type is similar to the conventional type except it has a nose wheel instead of a tail wheel. The bicycle type landing gear has the main gear located near the nose and tail sections of the fuselage. Small wheels, one under each wing, balance the aircraft on the ground. The B-52 has a variation of a bicycle type gear called quadricycle. The quadricycle has two main wheels near the nose section and two near the tail section.

Mark the following statements true (T) or false (F).

_____1. All aircraft have retractable landing gear.

_____2. There are two types of retractable landing gear.

_____3. Landing gear supports the aircraft in flight.

_____4. The B-52 has a quadricycle type landing gear.

Answers to Frame 44: F 1. T 2. T 3.

Frame 46

Miscellaneous aircraft systems such as instruments, air conditioning, de-icing, oxygen, water injection, fire warning, etc., will not prevent flying the aircraft if they are malfunctioning. However, for "Safety of Flight," and the protection of the aircrew and aircraft, the aircraft are not normally flown when any of the above systems are malfunctioning.

NO RESPONSE REQUIRED

Answers to Frame 45: F 1. F 2. F 3. T 4.

Frame 47

This completes another segment of this lesson dealing with major aircraft systems. In this final portion of the lesson, the station numbering system will be presented. This system is important to you the maintenance person because it will help you find components on an aircraft that you may have never worked on before. Some aircraft TOs refer to component positions on the plane by station number elements. Each element is made up of basically three or four numbers depending on where the component is located. The three numbers referring to components found in the main fuselage of the aircraft are known as the body station (BS), body buttock line (BBL), and water line (WL).

Body stations (BS) are distances measured in inches from a point forward of the aircraft's nose (called station number 0). The numbers increase as you go aft along the fuselage to the tail. Therefore, the number of the station tells how many inches from station 0 a component is.

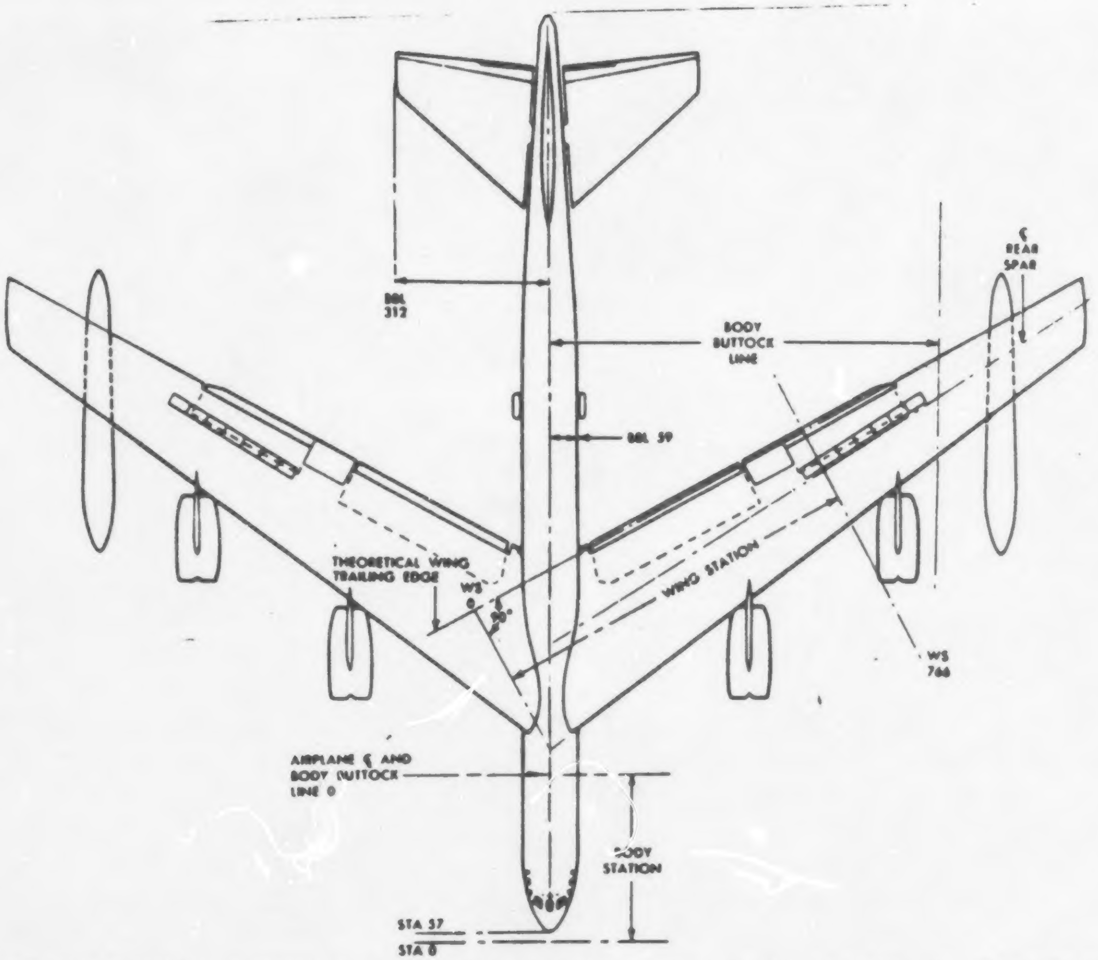
Body buttock lines (BBL) are distances measured left or right (in inches) from the centerline of the aircraft. Those on the left of the centerline are indicated by the letter "L"; those on the right, by the letter "R."

Water lines (WL) begin at WL 0 somewhere below the lowest part of the fuselage and increase as you go upward toward the top of the plane. These numbers are also measured in inches.

Thus, for any component in the main fuselage of the aircraft, these three numbers are sufficient to exactly define its position in the aircraft. However, if the component is found along or inside one of the wings, another number is required. This number is called the wing station (WS) number and is measured along either wing (left or right), beginning at the centerline of the aircraft and moving outward along the wing. This is also measured in inches. The figure on the next page summarizes the station numbering system.

Choose the correct answer for the following questions.

1. Body stations, body buttock lines, water lines, and wing stations are used in the
   - a. Air Force Technical Order system.
   - b. deficiency reporting system.
   - c. station numbering system.
   - d. data collection system.
2. The purpose of the station numbering system is to
   - a. aid in the location of various parts or units.
   - b. aid in the use of the data collection system.
   - c. be used in the number sequencing of aircraft.
   - d. aid in the identification of types of aircraft.

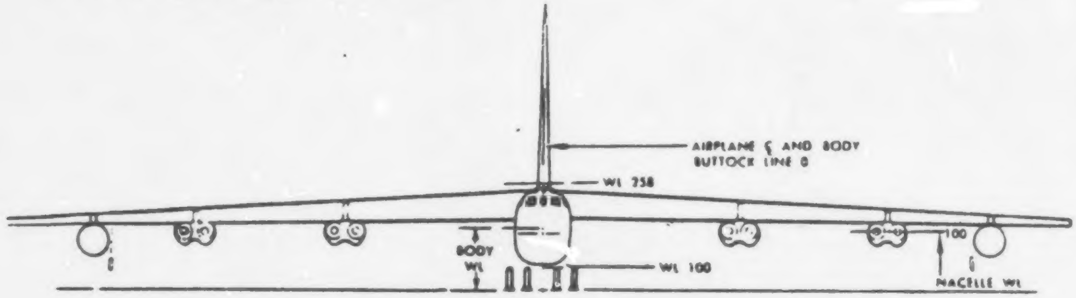

BBL 312
℄ REAR SPAR
BODY BUTTOCK LINE
BBL 59
THEORETICAL WING TRAILING EDGE
WS 0
90°
WING STATION
WS 766
AIRPLANE ℄ AND BODY BUTTOCK LINE 0
BODY STATION
STA 57
STA 0

BBL—BODY BUTTOCK LINE, DISTANCE IN A HORIZONTAL PLANE MEASURED FROM THE VERTICLE ℄ OF THE AIRPLANE BODY IN EITHER DIRECTION

WL—WATER LINE, DISTANCE MEASURED ABOVE A HORIZONTAL DATUM WITH THE BOTTOM OF THE BODY BETWEEN BODY STATIONS 369 AND 1185 AS WL 100

BS—BODY STATION, DISTANCE FROM A POINT 57 INCHES FORWARD OF THE NOSE TO A PLANE PERPENDICULAR TO THE BODY IN INCHES

WS—WING STATION


AIRPLANE ℄ AND BODY BUTTOCK LINE 0
WL 258
BODY WL
WL 100
100
℄
℄ NACELLE WL

Airplane Station Nomenclature Diagram.

Answers to Frame 46: No response required

Answers to Frame 47: 1. c, 2. a

This completes the test on Aircraft Familiarization. When you have completed this PT, and have no questions about its contents, you may take the appraisal.

165

104

PREPARE THE MAN

PROGRAMMED TEXT 3ABR32531-PT-105
3ABR42230-PT-105
3ABR32530-1-PT-803
3ABR32632B-PT-202
3ABR42132-PT-103
3ABR42231-PT-106

Technical Training

Avionics Instrument Systems Specialist
Instrument Repairman
Automatic Flight Control Systems Specialist
Integrated Avionics System Specialist
Pneudraulic Repairman
Environmental Systems Repairman

AVIONICS SAFETY

19 July 1973

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR32531-PT-105, 3ABR42230-PT-105, 3ABR32530-1-PT-803, 4 January 1973; 3ABR32531-PT-504, 3ABR42231-PT-108, 3ABR42230-PT-104, 3ABR42132-PT-117, 11 March 1970; 3ABR32530-PT-702, 3ABR32531-PT-504A, 3ABR42132-PT-118, 3ABR42230-PT-104A, 3ABR42231-PT-108B, 20 August 1970.
OPR: TAS
DISTRIBUTION: X
TAS 2800; TTOC - 7

Designed For ATC Course Use

DO NOT USE ON THE JOB

187

FOREWORD

This programmed text was prepared for use in the 3ABR32531, 3ABR42230, 3ABR32530-1, Instructional Systems and was validated using 31 students enrolled in the 3ABR32531 course and 35 students in the 3ABR42330 course. At least 90 percent of the students achieved the objectives as stated. The average time required to complete this text is 55 minutes.

OBJECTIVES

After completing this programmed text and without the aid of references, you will be able to identify:

1. The principal objective of ground safety.
2. Practices of good housekeeping as being an aid to safety, fire prevention and fire safety.
3. Apply precautions pertaining to electrical/electronic equipment.
4. Precautions to observe while working around danger areas.
5. The hazards of high intensity sound and the protective devices to use.
6. The radiation hazard symbol that applies to radioactive parts and material.

Note: The objectives will be completed to an overall accuracy of 80%.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Carefully study each frame until you understand its contents. You are required to identify or complete or match items to related situations. Specific instructions are given in each frame. Check the accuracy of your work by looking at the answer at the bottom of the following frame. If your response is incorrect, read the frame again and correct your error before going to the next frame. DO NOT HURRY!

GROUND SAFETY

Frame 1

Most accidents don't just happen. They are caused by unsafe acts of people. Safety education is the most effective tool in preventing these acts. Training is a particularly important accident prevention control; it gives each man a personal safety tool by developing habits of safe practice and operation. The principal objective of any safety program is to provide safe operating standards for ground operations that will aid in eliminating accident-causing sources.

Check the correct statement(s).

1. _____ Most accidents are "man made" and can be controlled.

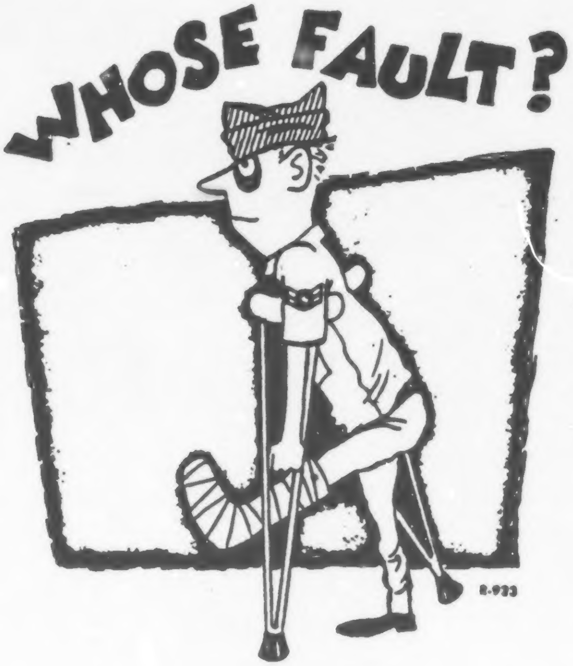
2. _____ Adequate safety education is the most effective way of preventing "man made" accidents.

3. _____ Training usually is ineffective in preventing accidents.

4. _____ One principal objective of any safety program is to eliminate accident-causing sources.

Frame 2

Accident prevention is the responsibility of management personnel such as commanders and supervisors. However, the person most responsible for your own safe work habits and attitudes can only be yourself. Unless you develop safe work habits and constantly practice safety, you or your fellow workmen may be injured.



Check the correct statement(s).

1. ____ If you are involved in an accident, you should always blame your supervisor.

2. ____ Being completely familiar with safe work procedures does not insure against accidents.

3. ____ Accident prevention is the responsibility of management personnel.

4. ____ You are responsible for your safe work habits.

Answers to frame 1:

1. ✓ 2. ✓ 3. ____ 4. ✓

Accidents involving handtools are usually the result of misuse. Just because handtools are simple devices does not mean they can be used safely by anyone with little or no training. Therefore, prevention of accidents involving handtools becomes a matter of proper instruction and adequate training in safe working practices.

Check the correct statement(s).

1. _____ Proper instruction is better than experience when learning to use handtools.

2. _____ Simple handtools are not dangerous; it is only their misuse that causes accidents.

3. _____ You should be taught handtool safety before using them.

4. _____ The misuse of handtools is not a violation of safety rules.

Answers to frame 2:

1._____ 2.__✓__ 3.__✓__ 4.__✓__

170

Frame 4

Screwdrivers are probably the most commonly used handtool. They are used for one purpose -- to loosen or tighten screws. If used for other purposes, they are misused. Common misuses of screwdrivers are as follows:

1. punches.
2. chisels.
3. pinch bars.
4. prys.
5. nail pullers.
6. hammers.
7. wedges.
8. scrapers.

The misuses listed above are dangerous to personnel, as well as damaging to the screwdrivers which makes them unsafe for further use.

Check the correct statement(s).

1. _____ You may misuse a screwdriver as long as you think it is a safe act.

2. _____ Damaged screwdrivers must not be used.

3. _____ Screwdrivers are designed for use on screws.

Answers to frame 3:

1.__✓__ 2.__✓__ 3.__✓__ 4._____

192

Misuse of files presents a safety hazard because of sharp cutting surfaces, tanged (pointed) ends, and brittle metal. The following safety practices will be observed when using files:

1. Do not use files without handles as pointed tangs can stab or cut your hand.

2. Clamp the work to be filed in a vise, never hold it in your hand while filing.

3. Do not use a file for a pry bar. The tang end is soft and will bend, while the body is hard and brittle and may snap.

4. Never hammer on a file. Remember, a file is brittle and may chip, splinter, or snap, scattering sharp fragments.

5. Old files should never be reshaped into knives, chisels or punches. They are too brittle to use for these purposes. Unexpected breaks could be dangerous.

Check the correct statement(s).

1. _____ You should not use a file without a handle.

2. _____ Files make good knives.

3. _____ An important reason for not misusing a file is the danger of breaks and chips.

Answers to frame 4:

1._____ 2.__✓__ 3.__✓__

Frame 6

Wrenches are frequently misused resulting in injury to personnel. The following practices will be observed concerning their safe use:

1. Use a wrench of the correct size. A loose wrench may slip and injure the hand.

2. Do not use wrenches with spread or distorted jaws, bent handles, or cracks.

3. Do not use a wrench as a hammer. To do so will weaken it.

4. Do not use a pipe or other device on a wrench handle for greater leverage. The wrench handle may snap and cause injury to personnel.

5. Never hammer on wrench handles to free frozen nuts.

6. Pull a wrench - never push it. You can maintain your balance easier by pulling.

Check the correct statement(s).

1. _____ Wrenches are not dangerous, it is only their misuse that is dangerous.

2. _____ If a wrench jaw is cracked, it may as well be used until it breaks.

3. ______ A wrench of the correct size, when used properly, will not slip.

Answers to frame 5:

1. ✓ 2. _____ 3. ✓

Hammers should be kept clean and free of oil or grease which would cause the handle to slip from the workman's hand or cause the hammer to glance off the object being struck. The ends of hammer handles will not be used for prying, pounding or tapping. This practice may damage and weaken the handle and lead to an accident.

Check the correct statement(s).

1. _____ Hammer heads should be kept greased to prevent rust.

2. _____ You should never put oil on hammer handles.

3. _____ You should not tap work with the end of a hammer handle.

Answers to frame 6:

1. ✓ 2._____ 3. ✓

Frame 8

The following safety rules apply to knives:

1. Keep knife blades sharp. Dull blades contribute to more accidents than sharp blades.

2. Use knives for cutting, never for a screwdriver or pry bar.

3. Do not leave knives lying around where they may cause injury. Keep pocket knives folded (closed) when not in use.

4. Cut away from the body, being careful to cut in a direction that will not endanger fellow workers should the knife slip.

Check the correct statement(s).

1. _____ If you sharpen a pencil with a pocket knife, place the end of the pencil on your thumb and cut toward your thumb.

2. _____ Pocket knives are dangerous unless used properly.

3. _____ Dull blades are more hazardous than sharp blades.

4. _____ Knives may be used for many jobs other than cutting.

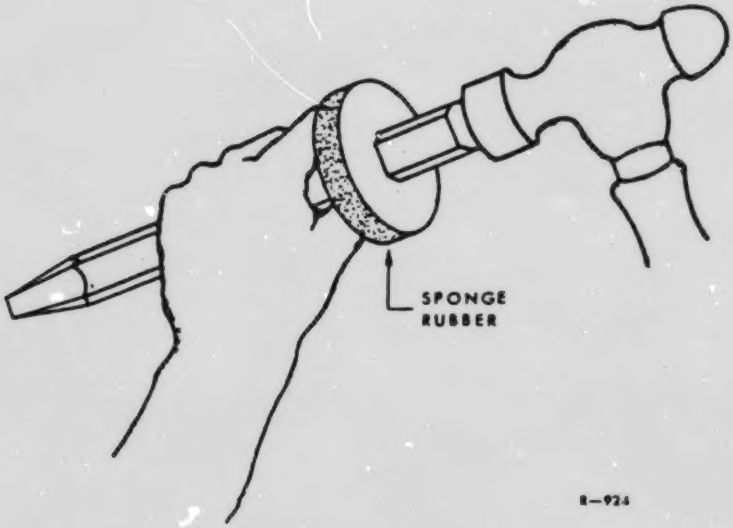
Answers to frame 7:

1._____ 2.__✓__ 3.__✓__

Frame 9

Punches and cold chisels will be kept free from grease and oil to prevent slippage. Hold these tools between the thumb and four fingers. If tools have become mushroomed they must be properly dressed or ground. If practical, hand guards such as sponge rubber will be used.

Workers will wear safety goggles or face shields whenever they strike chisels or punches.



8—924

Check the correct statement(s).

1. _____ A chisel becomes mushroomed on the end opposite from the cutting edge.

2. _____ Chisels cut better when the cutting edge is greased.

3. _____ Mushroomed punches should be dressed by grinding.

Answers to frame 8:

1._____ 2.__✓__ 3.__✓__ 4._____

176

Frame 10

Pliers and diagonal cutting pliers are often used around electrical equipment. Electrical equipment must be turned off when using these tools on electrical circuits. Pliers must not be used to tighten or loosen bolts and nuts. To do so may damage the bolt head or nut. Wrenches used on bolts or nuts thus damaged may slip and injure the hand.

Check the correct statement(s).

1. _____ Diagonal cutting pliers may be used on electrical circuits only after the electrical system is turned off.

2. _____ You must not use pliers to loosen nuts.

3. _____ You may use pliers on electrical equipment when the circuit is turned on if you wear rubber gloves.

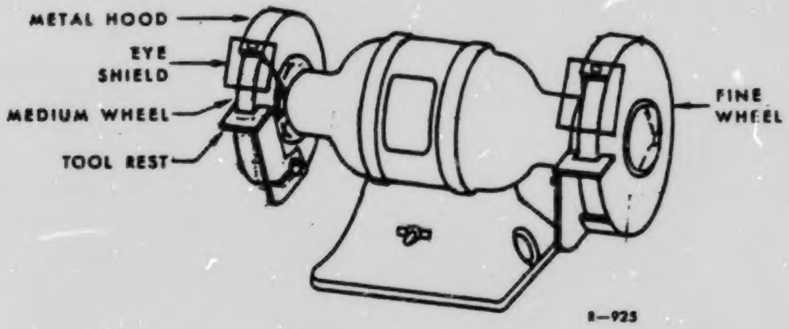
Answers to frame 9:

1. ✓ 2. _____ 3. ✓

198

Frame 11

Unsafe grinding practice can result in many serious injuries. In addition to the shatterproof glass shields, workers will wear protective goggles or face shields while operating grinding wheels. You must never operate a grinder with the metal hoods removed. Tool-rests will be adjusted to not more than one-eighth inch from the grinding wheel.



Check the correct statement(s).

1. _____ You must wear goggles or a face shield when grinding on an electrical grinder.

2. _____ While grinding large objects, you should remove the metal hood.

3. _____ Before grinding you must check the distance between the grinding wheel and tool-rest.

Answers to frame 10:

1. ✓ 2. ✓ 3. _____

Frame 12

Compressed air must be handled with care. If you use compressed air for cleaning parts you must wear eye protective equipment, such as goggles. It must never be used to blow dust from clothing or skin. Pressures as low as 10 to 15 pounds per square inch can cause serious injury to skin, eyes, ears, and penetrate the body. Horseplay with the air hose will not be tolerated. Under no circumstances will compressed air be directed toward a fellow worker.

Check the correct statement(s).

1. _____ You must use eye protectors or goggles while cleaning parts with compressed air.

2. _____ Compressed air must not be used to blow dust from your hair.

3. _____ Ten pounds of air pressure is too low to cause personnel injury.

Answers to frame 11:

1.__✓__ 2._____ 3.__✓__

Degreasing solvents are used to remove grease from parts. Some of these agents are poisonous when in contact with the skin, taken internally, or inhaled. Trichloroethylene, a nonflammable degreasing solvent, is a narcotic and anesthetic material. An accumulation in the body, due to prolonged exposure, can cause anemia and liver damage. Use trichloroethylene outdoors or in a well ventilated building. You must not expose your skin to this solvent or breathe its vapors.

Check the correct statement(s).

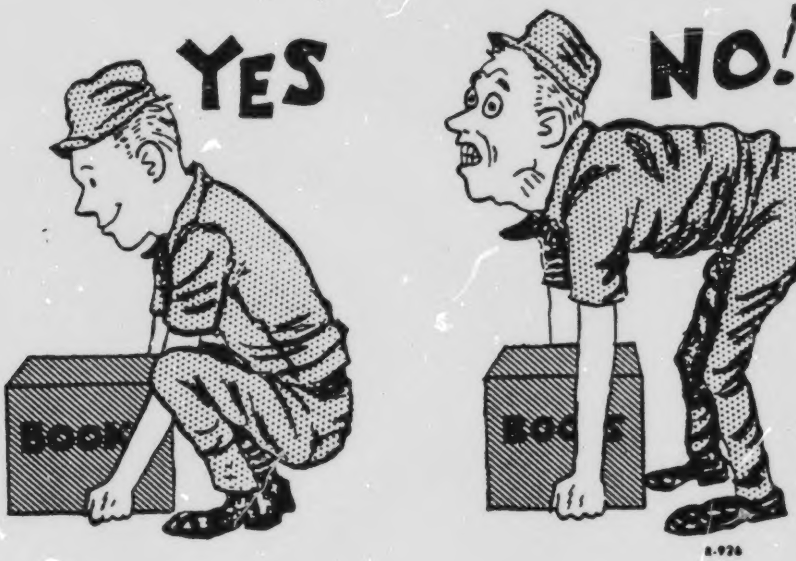
1. _____ Trichloroethylene must not come in contact with the skin.
2. _____ You must not breathe vapors of trichloroethylene.
3. _____ Trichloroethylene is not a hazard if skin exposure is for short periods.

Answers to frame 12:

1._✓_ 2._✓_ 3._____

Frame 14

Hernias, back strains, crushed hands and feet, and broken bones may result from improper lifting. Lift from a squatting position with the back straight. The legs should exert the primary lifting force as shown in the "Yes" figure below.



Check the correct statement(s).

1. _____ When lifting, the back should be the main lifting force.

2. _____ The figure on the left is an illustration of a workman lifting with the legs.

Answers to frame 13:

1.__✓__ 2.__✓__ 3._____

You may think it impossible to remember all the safety procedures while performing your daily work. However, it is not difficult to remember that Air Force rules and instructions are written and published for your use. You must use these written rules, regulations, and instructions as you perform your daily work. Do not rely upon your memory when personnel safety is involved. If you perform your work correctly by following written instructions, the possibility of accidents will be reduced. Above all, never engage in horseplay and always use common sense. Keeping these facts in mind will help you perform your daily work in a safe and efficient manner.

No Response Required

Answers to frame 14:

1._____ 2._✓__

203

182

Frame 16

Check the following statements that are correct.

1. ______ Accidents are sometimes caused by lack of safety training.

2. ______ Each worker is directly responsible for his own safe work habits.

3. ______ Learning to use handtools properly involves training in safe use of handtools.

4. ______ Screwdrivers are handy tools and should be used when other tools such as pry bars and chisels are not available.

5. ______ One hazard connected with misuse of files is possible breakage due to brittle metal.

6. ______ If a nut is "frozen," you should tap the wrench handle with a hammer.

7. ______ A hammer with a split handle should be used until you can get a new hammer or replace the split handle.

8. ______ When cutting with a knife, cut away from the body, not toward it.

9. ______ Danger from mushroomed punches and chisels results from possible hand cuts or flying chips from the tool.

10. ______ Pliers must not be used on bolts and nuts.

11. ______ Grinding wheel tool-rests must be not more than one-eighth inch from the grinding wheels.

12. ______ The principal object of any safety program is to aid in eliminating accident-causing sources.

13. ______ There is no special danger connected with the use of compressed air for cleaning parts.

14. ______ The greatest danger in using trichloroethylene is the extreme fire hazard.

15. ______ You should lift with your legs, not your back.

Frame 17

Good housekeeping and accident prevention go together. Shops must be kept neat and orderly. All persons must cooperate to keep their work area clean, orderly, and SAFE. Serious accidents could result from tripping over trash, hardware, tools or electrical power cords on floors. Liquids spilled on floors produce slippery surfaces that are particularly dangerous. Keep walking areas clear and clean.

Check the correct statement(s).

1. _____ Possible electrical shock is usually the greatest hazard resulting from power cords lying on the floor.

2. _____ If a tool is dropped on the floor, it should be picked up immediately.

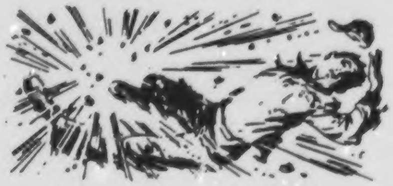
3. _____ Oil on the floor is a source of accidents as well as a fire hazard.

Answers to frame 16:

1. ✓
2. ✓
3. ✓
4. _____
5. ✓
6. _____
7. _____
8. ✓
9. ✓
10. ✓
11. ✓
12. ✓
13. _____
14. _____
15. ✓

Frame 18

Tools must be stored in their proper place, either in the tool kits or on special tools racks. Good habits concerning tool storage and care are essential to efficient and safe job performance. Keep all of your tools in good condition. Clean, sharp, and well selected tools are the mark of a professional systems specialist. Greasy tools used on oxygen equipment are a sure way of causing an explosion and fire.



KEEP OIL AND GREASE AWAY FROM OXYGEN

No Response Required

Frame 19

Lockers, cabinets, shelves, and drawers must be kept neat and orderly. These areas require constant attention as their contents are usually hidden from direct vision. Heavy objects should be stored on bottom shelves to lessen lifting or dropping hazards. Drawers and cabinet doors should not be left open as they usually protrude into the walking area when open.

Check the correct statement(s).

1. _____ Orderly arrangement of drawer and cabinet contents is a safety requirement.

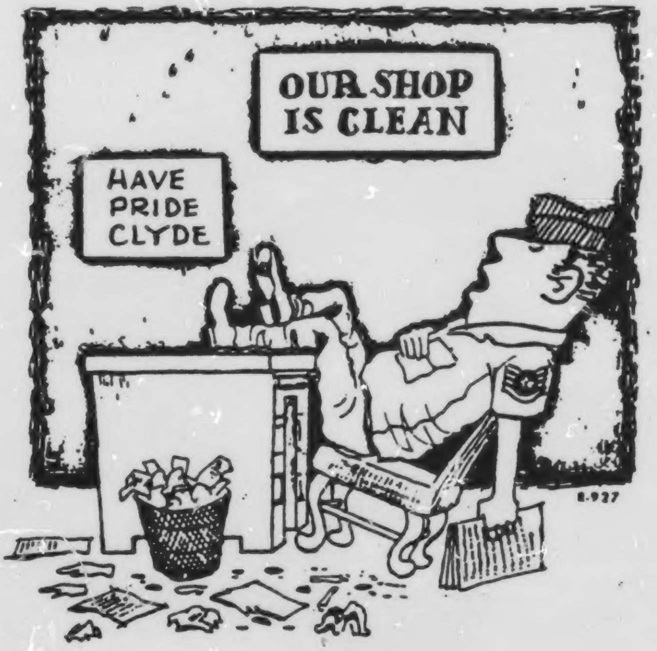
2. _____ Drawers and cabinet doors should not be left open.

3. _____ Lighter objects should be stored on bottom shelves, heavy items on top shelves.

Answers to frame 17:

1._____ 2.__✓__ 3.__✓__

Good housekeeping practices are essential to effective fire prevention. Working and living areas must be kept clean and orderly as accumulations of dust, trash, rubbish, and waste are sources of fire. Every man shares the fire prevention responsibility within his working and living area.



Check the correct statement(s).

1. _____ You should not be concerned with good or bad housekeeping practices in your shop because that is the responsibility of your supervisor.

2. _____ Good housekeeping is concerned with cleanliness in the work area.

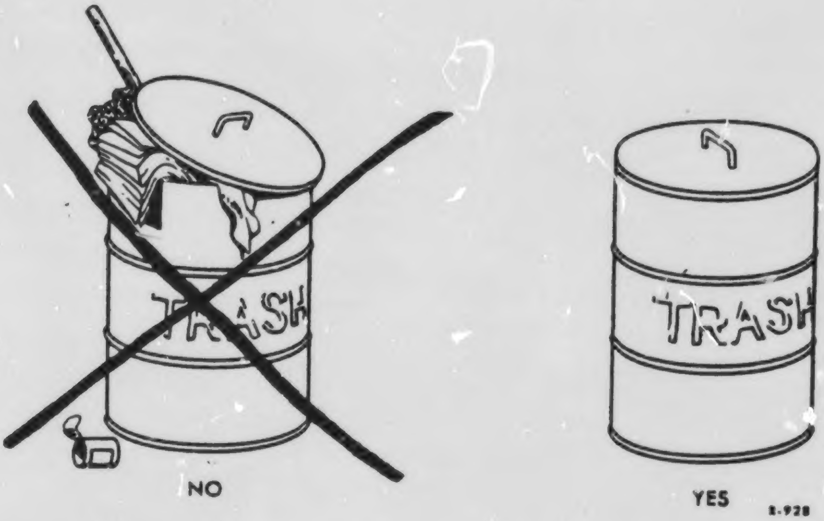
3. _____ Bad housekeeping practices may cause fires.

Answers to frame 19:

1._✓_ 2._✓_ 3._____

Frame 21

Combustible trash must be placed in closed metal containers that are plainly marked for such materials as shown in the figure below. Lids must be kept closed. At the end of the day or shift, these containers must be emptied or removed to a safe location outside the shop.



Check the correct statement(s).

1. _____ Noncombustible trash must be placed in closed metal containers.

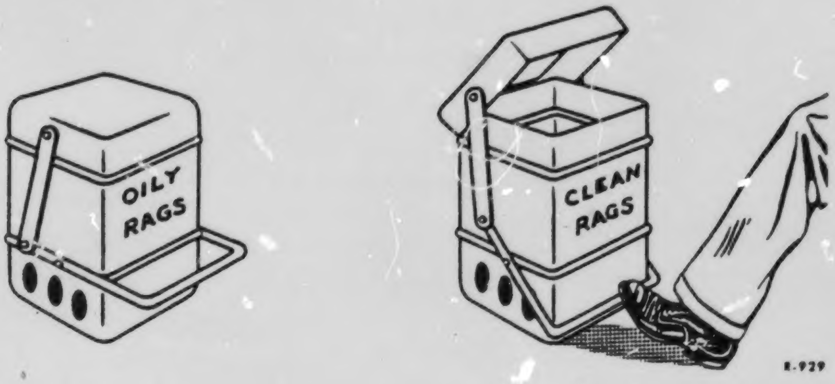
2. _____ You need not empty trash cans until they are full.

3. _____ Metal trash cans with lids tightly closed may be kept in the shop during working hours.

Answers to frame 20:

1._____ 2.__✓__ 3.__✓__

Oil and paint soaked rags must not be placed in trash cans. Self-closing metal containers will be used for this material. A separate closed metal container must be used to store clean rags. Containers will be marked as shown in the figure below. Do not put oily and clean rags in the same container. Care must be taken to prevent oil rags from bursting into flame through spontaneous combustion. Empty the oil rag containers, or place them in a safe location outside the building at the end of each day or shift.



Check the correct statement(s).

1. _____ Trash should not be placed in an oily rag container.

2. _____ Clean rags, in their metal container, present a fire hazard and should be removed from the building at the end of the day or shift.

3. _____ Paint soaked rags should be discarded by placing them in a metal trash can.

4. _____ Oily rags present a special fire hazard because of possible spontaneous combustion.

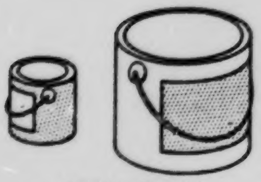
Answers to frame 21:

1._____ 2._____ 3. ✓

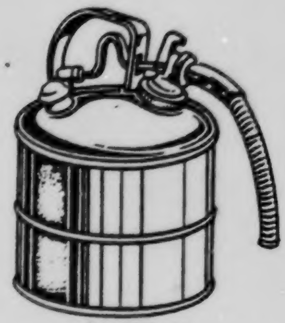
Frame 23

188

Oils, paints, cleaning solvents or other volatile liquids must be stored in closed metal containers in designated areas outside of shop buildings. A "safety can" with a flexible spout is a safe container for flammable liquids such as gasoline and cleaning solvents. These containers are shown below.



METAL CANS



SAFETY CAN

E-930

Check the correct statement(s).

1. _____ Flammable liquids must not be stored in the shop.

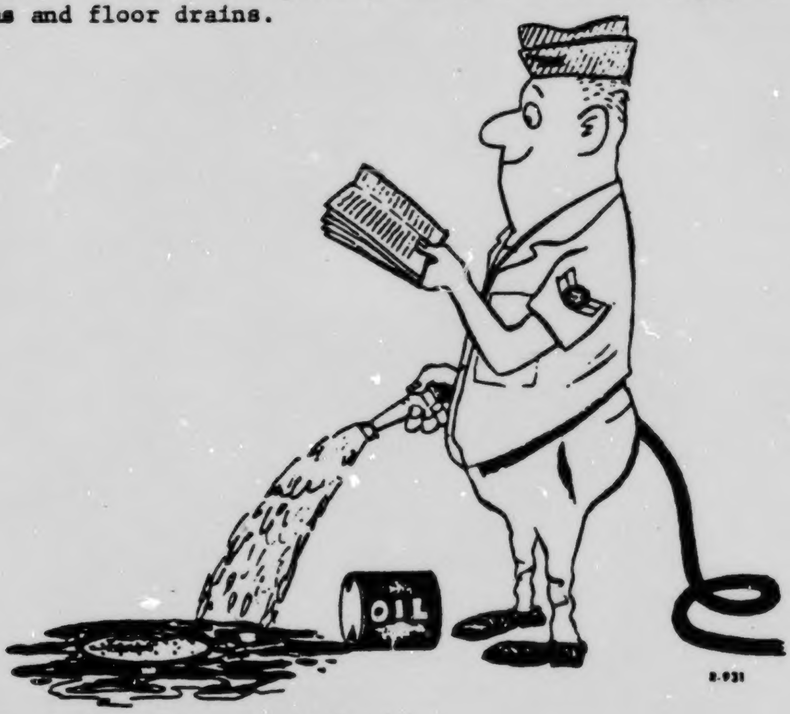
2. _____ Oil does not evaporate rapidly so it may be stored in open cans.

3. _____ Cleaning solvents will be stored in "safety cans."

Answers to frame 22:

1. ✓ 2. _____ 3. _____ 4. ✓

Oil, grease, and other flammable substances spilled on floors will not only create fire hazards, but also slipping hazards. If spills do occur, they must be cleaned immediately with noncombustible absorbents such as sand. Floors will not be cleaned with flammable liquids nor will these liquids be flushed into building plumbing systems and floor drains.



Check the correct statement(s).

1. _____ To reduce fire hazards, water should be used to flush dirty oil down a drain.

2. _____ If you spill a flammable solvent on the shop floor you must clean it up immediately.

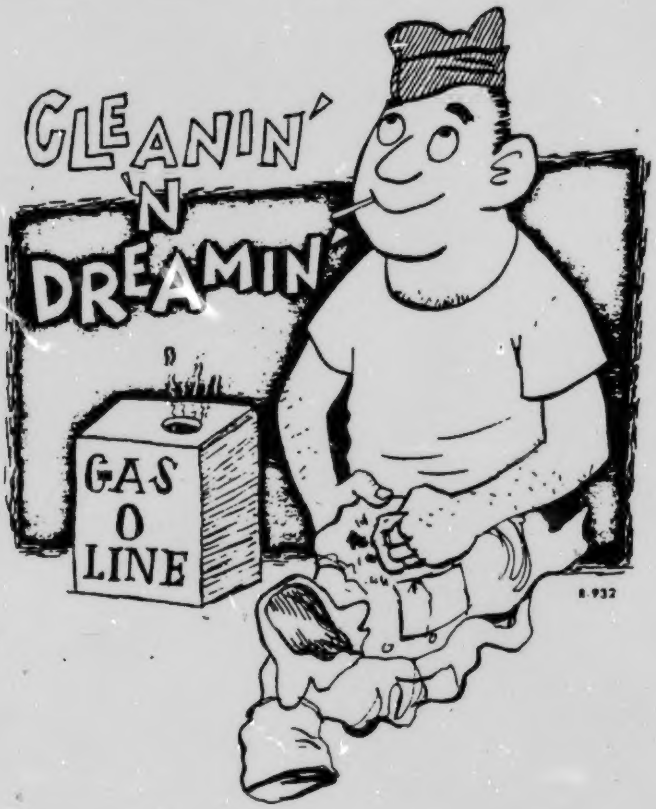
3. _____ Gasoline should not be used to clean up spilled oil.

Answers to frame 23:

1.__✓__ 2._____ 3.__✓__

Frame 25

Liquids such as gasoline, jet engine fuel, and flammable solvents must not be placed in open containers near electrical equipment. Flammable solvents will not be used for cleaning fatigue clothing or used in cigarette lighters. Vapors from these liquids are explosive and may ignite unexpectedly.



Check the correct statement(s).

1. _____ Gasoline may be used for cleaning purposes.

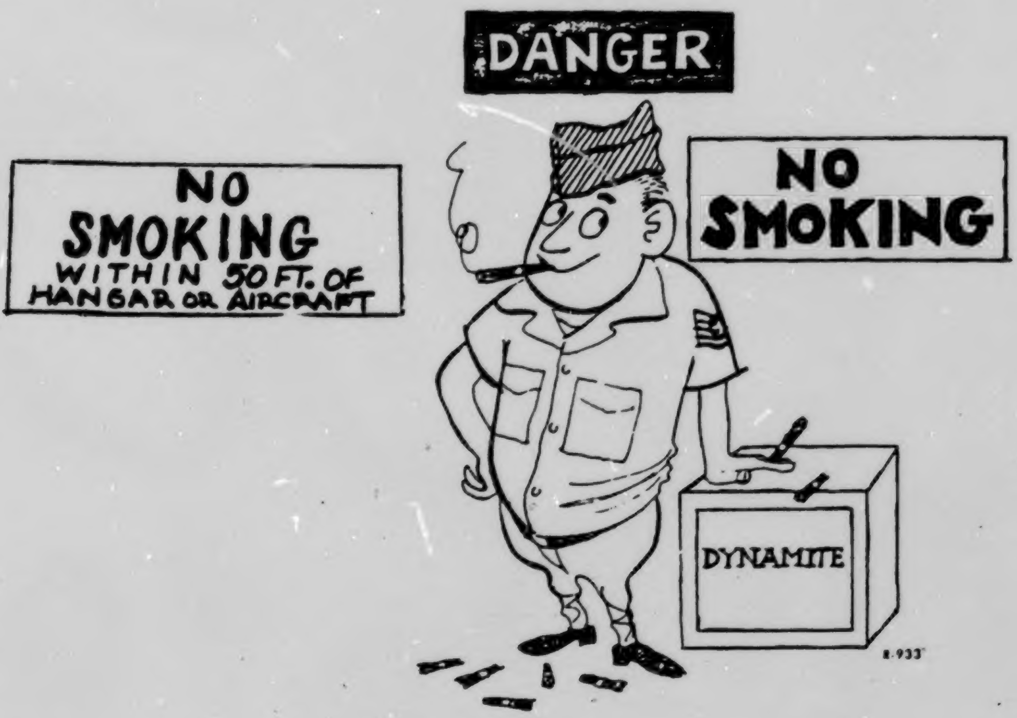
2. _____ Some solvents are flammable.

3. _____ Flammable solvents must not be used near electrical equipment.

Answers to frame 24:

1._____ 2.__✓__ 3.__✓__

Smoking is prohibited in areas in which a match, flame, spark, or careless disposal of smoking material would be a fire hazard. Look for "NO SMOKING" signs in these areas. Where complete prohibition of smoking is impractical, certain areas will be clearly marked and separated from hazardous areas to stop the possibility of fire. Cigarette butts and burned matches must not be placed in trash cans. Special "butt cans" will be provided for this purpose.


DANGER
NO SMOKING WITHIN 50 FT. OF HANGAR OR AIRCRAFT
NO SMOKING
DYNAMITE
8.933

Check the correct statement(s)

1. _____ You may smoke in specified smoking areas.

2. _____ You must not smoke in areas where smoking is prohibited.

3. _____ Cigarette butts must be discarded in trash cans.

4. _____ You must not smoke within 50 feet of a hangar or aircraft.

Answers to frame 25:

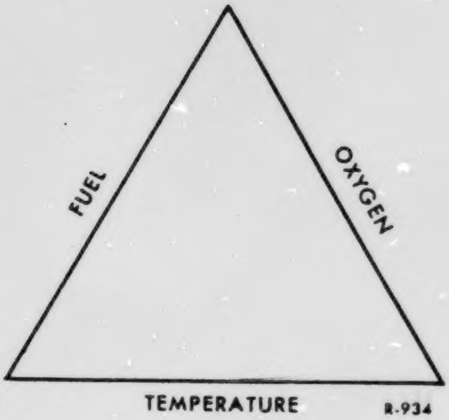
1._____ 2.__✓__ 3.__✓__

Frame 27 192

The following ingredients are necessary to produce fire:

1. Fuel (gasoline, wood, paper, rags, etc.).
2. Oxygen (air).
3. Temperature high enough to cause combustion.

Elimination of any one of these will extinguish the fire.



Check the correct statement(s).

1. _____ Gasoline will not burn without oxygen.

2. _____ Oxygen will burn without fuel.

3. _____ A fire may be extinguished by reducing the temperature.

Answers to frame 26:

1. ✓ 2. ✓ 3. ____ 4. ✓

21?

There are three general classes of fires. They are Class A, Class B, and Class C fires. Each fire is classified according to the type of fuel that is burning.

Check the correct statement(s).

1. _____ The class of fire is determined by the ignition temperature of the fuel.

2. _____ Class A, B, and C refers to types of fuel.

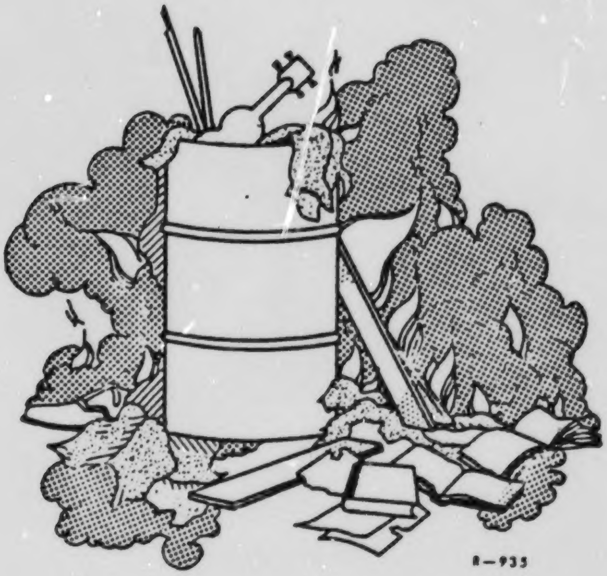
Answers to frame 27:

1._✓_ 2._____ 3._✓_

194

Frame 29

Fires in wood, paper, and rags are typical Class A fires. They will be safety extinguished by cooling or quenching the fire with water.



Check the correct statement(s).

1. _____ Burning waste paper is a Class A fire.

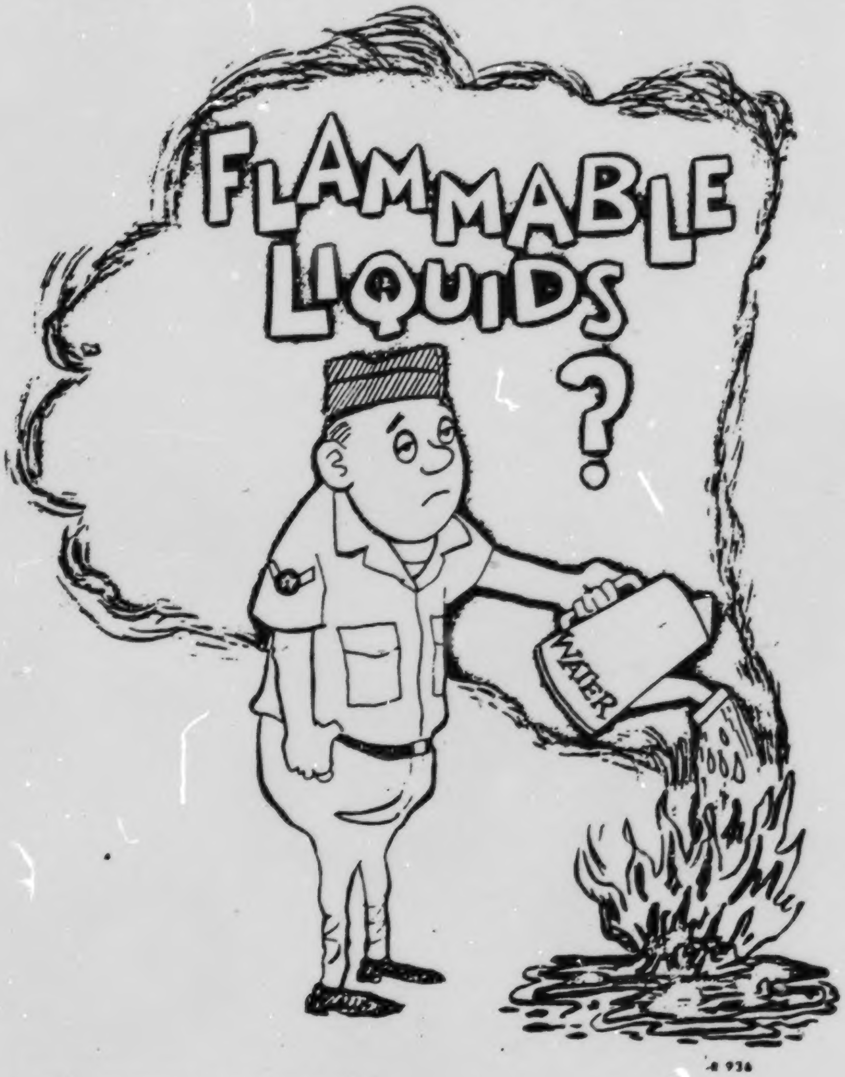
2. _____ Burning gasoline is a Class A fire.

3. _____ Water will spread a Class A fire.

Answers to frame 28:

1._____ 2._✓___

Class B fires are fires in flammable liquids such as gasoline, oil, and paint. These fires cannot be extinguished with water. They require fire extinguishers containing smothering agents such as foam.



Check the correct statement(s).

1. _____ Foam cannot extinguish grease fires.

2. _____ Foam is a suitable extinguishing agent for Class B fires.

3. _____ A burning liquid is a Class B fire.

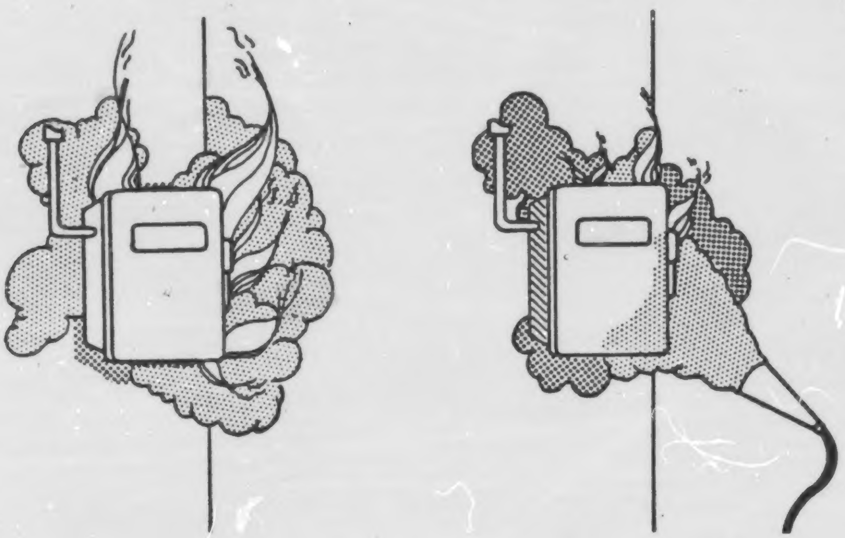
Answers to frame 29:

1.__✓__ 2._____ 3._____

Frame 31

196

Electrical fires are Class C fires. Electrical shorts in wires, motors, and generators produce heat which causes combustible materials in these electrical units to burn. Electrical fires must be extinguished with nonconducting smothering agents such as chlorobromomethane (CB). Do not use water on electrical fires as water conducts electricity and you could receive a severe or fatal shock.



Check the correct statement(s).

1. _____ CB should be used on Class C fires.

2. _____ Water may be used on electrical fires.

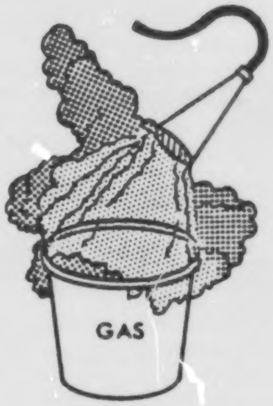
3. _____ Class C fires are electrical fires.

Answers to frame 30:

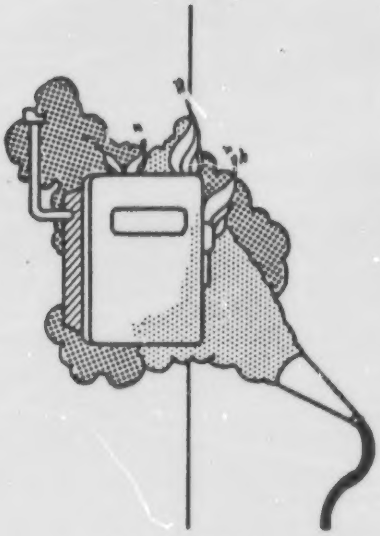
1._____ 2._✓_ 3._✓_

218

Chlorobromomethane can also be used to smother Class B fires. Remember, the chemical CB can be used on both Class C and B fires. (CB on C and B fires.)



CLASS B FIRE



CLASS C FIRE

B—938

Check the correct statement(s).

1. _____ CB can be used to extinguish oil or an electrical generator fire.

2. _____ Class A fires should be extinguished with CB.

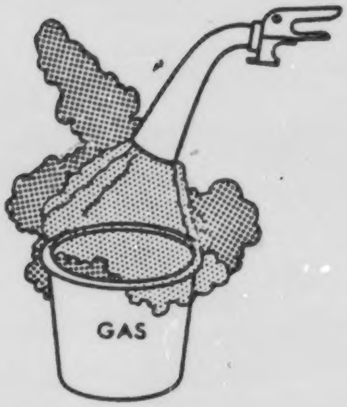
3. _____ CB extinguishes fires by excluding the air from the fuel (smothering the flame).

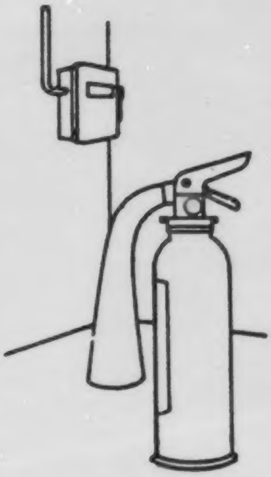
Answers to frame 31:

1.__✓__ 2.______ 3.__✓__

Frame 33

Carbon dioxide (CO_2) is another chemical that can be used on Class B and C fires. CO_2 smothers a fire by displacing the air surrounding the fire. CO_2 is a nonconductor of electricity, so may be safely used on electrical fires. It may also be used to extinguish typical class A fires.





Check the correct statement(s).

1. _____ CO_2 should be used on burning wood.

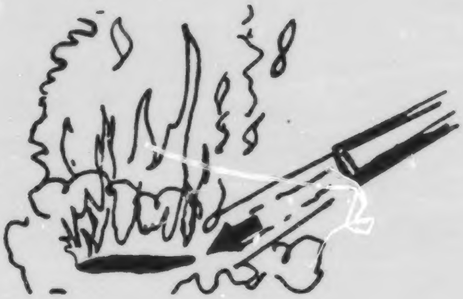
2. _____ CO_2 smothers a fire.

3. _____ CO_2 or CB may be used to extinguish electrical and flammable liquid fires.

Answers to frame 32:

1. ✓ 2. ____ 3. ✓

Fire extinguishing agents must be directed at the base of the fire, where the combustible vapors combine with air and ignite. "Aim" the extinguisher nozzle at the surface of the material where the flames originate.



Check the correct statement(s).

1. _____ Combustible vapors combine with air at the base of the fire.

2. _____ You should "aim" the extinguisher nozzle at the base of the fire.

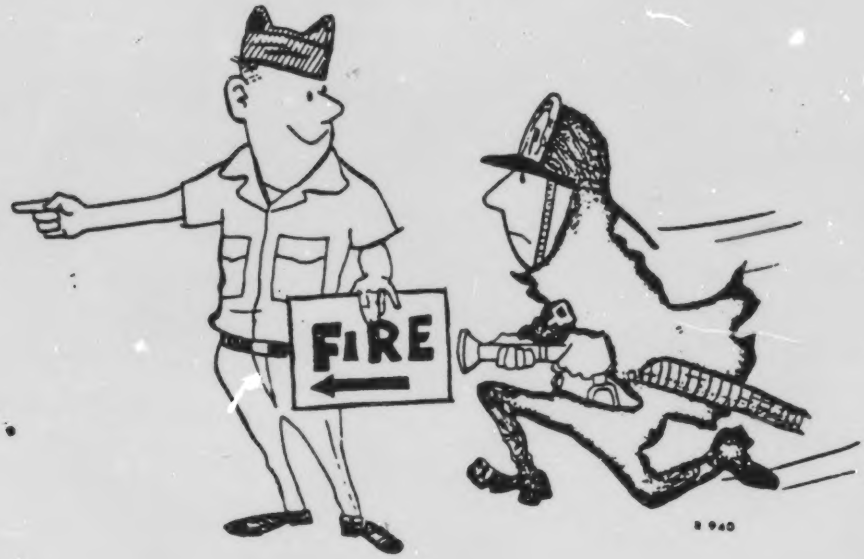
3. _____ The base of the fire is the top of the blaze.

Answers to frame 33:

1._____ 2.__✓__ 3.__✓__

Frame 35

If you report a fire, give your name and location of the fire, and then stand by to direct the fire crews to the fire.



No Response Required

This frame is a review of the material on housekeeping and fire safety. Check the following statements that are correct.

1. _____ There is no relationship between fire prevention and good housekeeping.

2. _____ Gasoline should be used for cleaning parts.

3. _____ Oily rags should be stored in closed metal containers.

4. _____ Fuels, cleaning solvents, and paints should be stored in the shop.

5. _____ Common causes of fires are poor housekeeping and careless use of flammable liquids.

6. _____ Water is a good extinguishing agent for Class A fires.

7. _____ Grease fires are Class B fires.

8. _____ Burning jet fuel should be extinguished with water.

9. _____ Electrical fires are Class A fires.

10. _____ CB is carbon dioxide.

11. _____ Carbon dioxide may be used to extinguish electrical fires as well as flammable liquid fires.

12. _____ Chlorobromomethane may be used on electrical fires.

13. _____ Extinguishing agents should be directed at the top of the blaze to smother the fire.

14. _____ Class B fires can be extinguished by using extinguishers containing smothering agents such as foam.

Answers to frame 34:

1._✓_ 2._✓_ 3._____

Frame 37

SAFETY PERTAINING TO ELECTRICAL/ELECTRONIC EQUIPMENT

DANGER

HIGH VOLTAGE

Here is a sign many of us are familiar with. Voltages present in shops throughout the world vary somewhat: 110 - 220 - 440, etc.

You will be working on systems that operate on AC and DC voltage. You must be constantly alert for shock hazards, and remember - it takes as little as 10 milliamperes (.01 ampere) of current to prove fatal. Some persons have been fatally injured on even less.

The proper attitude toward electricity is "don't fear it - understand it and respect it."

Check the correct statement(s).

1. _____ Systems with less than one ampere of current flow are not dangerous.

2. _____ Systems with less than one ampere of current flow can be fatal.

3. _____ The amount of voltage in shops may vary from one location to another location.

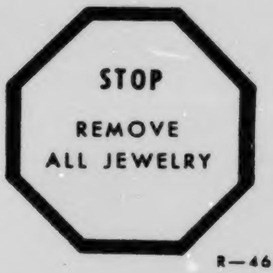
Answers to frame 36:

1._____ 2._____ 3. ✓ 4._____ 5. ✓ 6. ✓ 7. ✓

8._____ 9._____ 10._____ 11. ✓ 12. ✓ 13._____ 14. ✓

Frame 38

While working around electrical or electronic circuits you must remove your rings, metal wrist band, watch, or other metallic objects which could act as conductors of electricity and cause shocks, burns, or electrocution. So, form the habit of removing jewelry before doing electrical/electronic work or while performing maintenance on or around aircraft. Repeated exposure to shock may cause bursitis, contraction or dilation in the walls of blood vessels, and muscles can be seriously affected.



R—461

Check the correct statement(s).

1. ____ Severe burns can result from rings, contacting "live" electrical circuits.

2. ____ Wearing a wrist watch on the arm is a potential hazard while working on "live" electrical circuits.

3. ____ Repeated exposure to electrical shock has no after effect on the body.

Answers to frame 37:

1.____ 2.__✓__ 3.__✓__

Frame 39

Due to the many different systems that employ electrical/electronic principles, we will not attempt to list the safety precautions that may be involved in each. However, before performing maintenance on these systems, you will comply with all the instructions contained in the appropriate technical orders, manuals, handbooks, and/or applicable directives. Below are examples taken from a technical order on a B-52D type aircraft.

CAUTION

WARNING

If you observe an individual being electrically shocked, DON'T JUST STAND THERE - DO SOMETHING! First, shutoff the circuit. If the circuit cannot be turned off without delay, free the victim from the live conductor. Remember:

1. DO NOT touch the victim with your bare hands.

2. Protect yourself by using dry insulating material:

   a. a dry board, your belt, dry clothing or other non-conducting material.

Check the correct statement(s).

1. _____ An aircraft technical order will list any electrical hazard peculiar to a system.

2. _____ The bare hands should never be used to remove a shock victim from a live circuit.

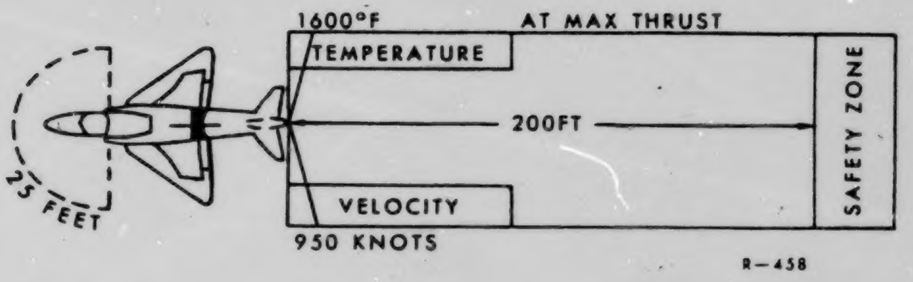
3. _____ A shock victim should not be removed from a live circuit, under any circumstances, until the circuit is turned off.

Answers to frame 38:

1. ✓ 2. ✓ 3._____

Frame 40

The flight line can be a very interesting and fascinating place due to aircraft taxiing back and forth, some being towed, and others parked on the ramp. In these situations it's easy to forget the hazards that forever lurk about on the flight line. One area where only one mistake can cost your life is the exhaust of an operating jet engine. Directly behind the engine, the temperature is 1600°F, and the velocity is 950 knots. Imagine yourself absent-mindedly stepping behind this death trap. Never come any closer to the exhaust of an operating jet engine than 200 feet, and this includes while you are in a vehicle. Remember, lack of knowledge, improper attitude, and inattention are the real hazards.



Check the correct statement(s).

1. _____ The safe distance behind an operating jet engine is 200 feet.

2. _____ Safety is not easily forgotten on the flight line.

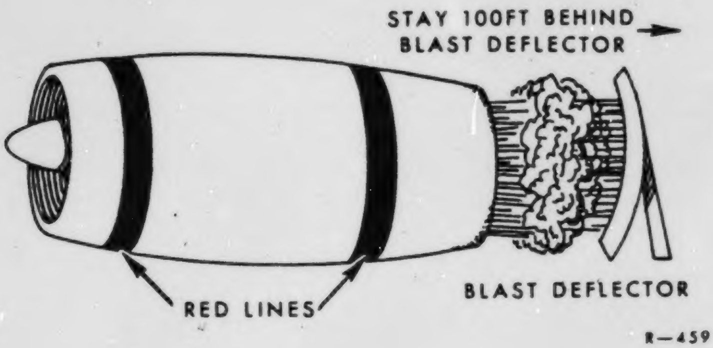
3. _____ Temperature and velocity is not a safety factor if the engine is not operating at maximum thrust.

Answers to frame 39:

1.__✓__ 2.__✓__ 3._____

Frame 41

If blast deflectors are positioned behind the engine being operated, then it is permissible to come within 100 feet of the exhaust. The blast deflector, besides reducing physical hazards, also prevents nuts, bolts, rocks, sticks, and other rubbish more commonly known as F O's (Foreign Objects) from being blown on to active runways and taxi-ways.



R—459

Check the correct statement(s).

1. _____ If deflectors are used, the only hazards that exist are F O's.

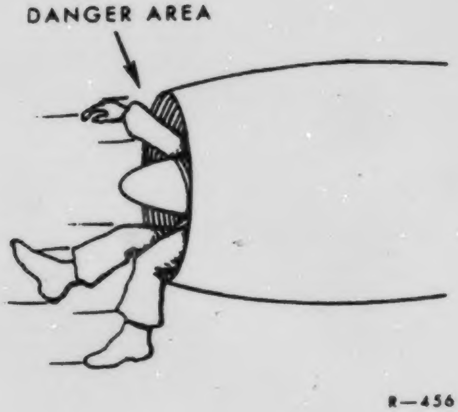
2. _____ Using deflectors prevents F O's from blowing on to taxi-ways.

3. _____ 100 feet is a safe distance behind exhausts if deflectors are used.

Answers to frame 40:

1.__✓__ 2._____ 3._____

Jet engines have huge appetites, and will consume anything in the immediate area. The minimum distance you should be from an operating jet engine intake (see frame 40) is 25 feet. Keep all nuts, bolts, screws, and tools off the intake cowling and out of the reach of the intake. Any one of these items could result in the loss of the aircraft and crew. Always report missing tools which might have fallen into the engine.



Check the correct statement(s).

1. _____ You should stay 25 feet from the intake of an operating jet engine.

2. _____ If you lose a tool, get it when the aircraft returns.

3. _____ Laying tools on the intake is okay as long as you pick them up later.

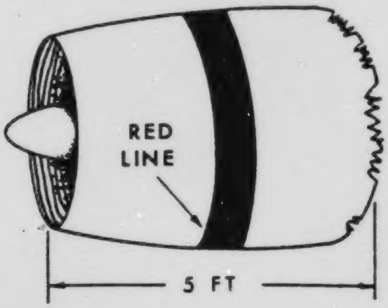
4. _____ Keep all nuts, bolts, and screws picked up.

Answers to frame 41:

1._____ 2.__✓__ 3.__✓__

Frame 43

There will be times when you have to work around the engine while it is operating, expecially checking systems where test equipment can not simulate an "engine run." If this is the case, you should stay a minimum of 5 feet to the rear of the intake as illustrated in the picture below.



R—457

Check the correct statement(s).

1. _____ You should stay a minimum of 5 feet to the rear of an operating jet engine.

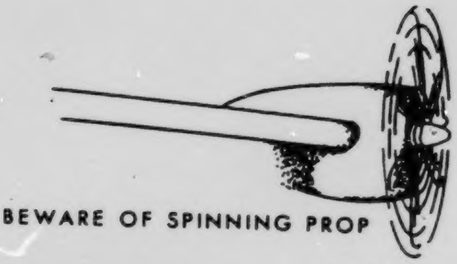
2. _____ You will not work around a jet engine while it is operating.

3. _____ You will be working around the engine while it is operating to check out some of your systems.

Answers to frame 42:

1.__✓__ 2._____ 3._____ 4.__✓__

Devices rotating at tremendously high rpm (revolutions per min) might disintegrate. Therefore, we must be well aware of where these hazards exist. Note the red lines around the engine in frame 43. These indicate the plane of rotation of the engine's turbine wheels. When possible you should stay clear of these areas. On aircraft with reciprocating engines, there will be red lines painted around the fuselage to indicate the planes of rotation of the propellers. The tips of the propellers will be painted yellow so they will be visible while spinning. This is to help prevent someone from walking into them.



R—460

Complete the following statements.

1. The propeller tips are painted_______________in color so they will be ___________________while spinning.

2. The red bank around the fuselage of a jet engine indicates the ____________of______________of the turbine wheel.

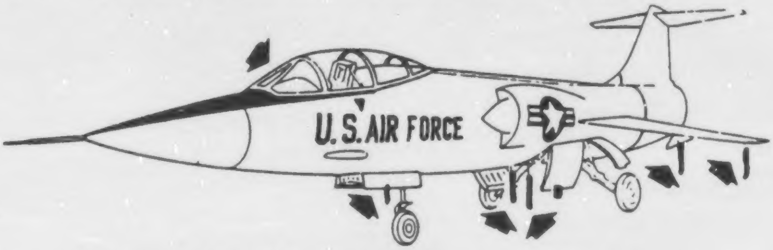
3. Devices that rotate at high revolutions per minute are dangerous because they might______________________.

Answers to frame 43:

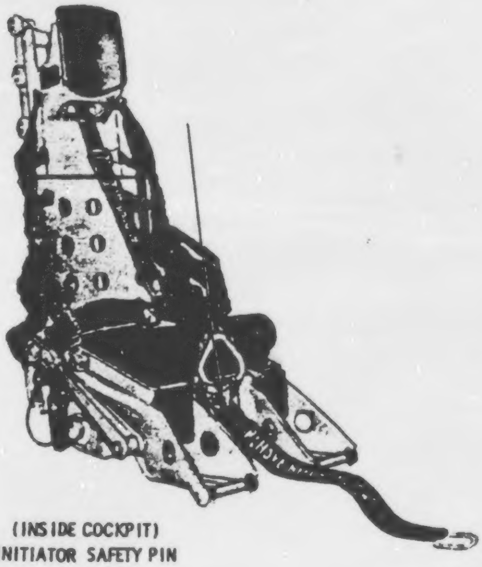
1._____ 2._____ 3._✓___

Frame 45

Before you enter an aircraft make certain someone has installed the gear down lock safety pins. These pins prevent the aircraft from collapsing on you. They are easily identified by the red streamers attached to them and the words "remove before flight."



Once you have seen that these pins are installed (see photo), look in the cockpit (jet aircraft) and see if similar pins have been installed in the ejection seats. These seats are real killers if you trigger one of them. If they have no pins and streamers — DON'T GET IN. Notify the crewchief immediately. It takes a specialist that understands them to render the seats harmless. See the photo to the right.



(INSIDE COCKPIT)
INITIATOR SAFETY PIN

Complete the following statement.

It is permissible to work in the aircraft if red streamers and ________________ ______________are installed in the proper places.

Answers to frame 44:

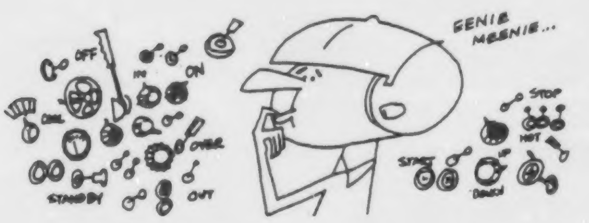
1. yellow visible (seen or something to that effect)

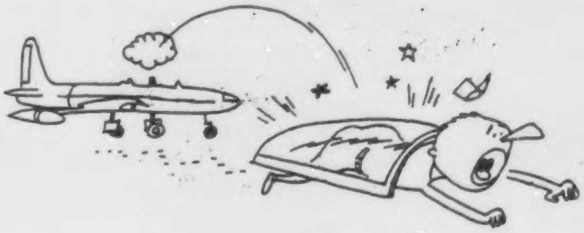
2. plane of rotation

3. disintegrate (fly apart)

Frame 46

When you must work in the cockpit area, respect your lack of knowledge of other systems. Also, beware of flipping switches, pushing buttons, and moving levers which could cause drop tanks to fall, a drag chute door or speed brake surface to open, or a bomb bay door to close on someone and shear him in half. Usually, a sign will be displayed if an out-of-the-ordinary hazardous condition exists in which someone might be injured.





Complete the following statement:

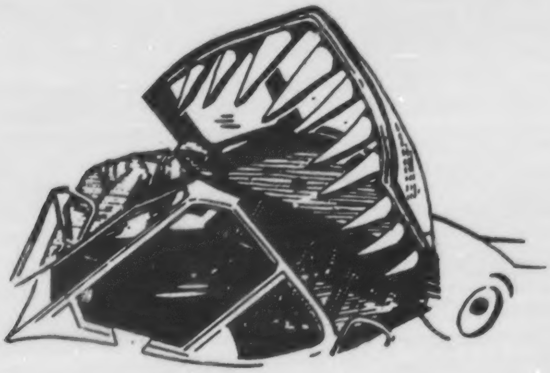
When a job requires you to be in the cockpit area, you should never____ that is not associated with your systems.

Answer to Frame 45:

Safety Pins

Frame 47

Wing and door edges are razor sharp on some aircraft and have been known to cause serious cuts and scars. Wings are extremely slippery after a rain or early morning dew. If you slip from a wing, you can be sure concrete is waiting below. Fast acting canopies account for many accidents involving the amputation of arms and whatever else might get in their way.

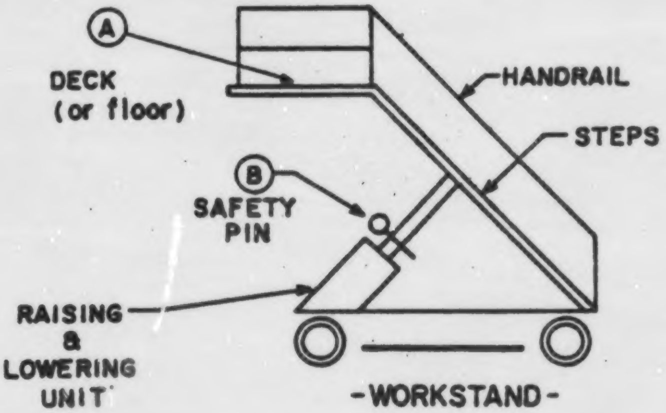


No Response Required

Answer to frame 46:

flip switches, push buttons or move levers (or similar wording).

Work on aircraft frequently calls for the use of maintenance stands. These stands come in an assortment of sizes and designs. Regardless of the purpose for which a particular stand was intended, you will find that once you have climbed aboard, a fall from it could cause serious injury. For this reason, handrails and/or safety pins are provided with them. Stands with removable railings will be in place before maintenance personnel begin working on aircraft from these stands.



The handrail (A) provides a gripping surface and will, if you should stumble, keep you from taking a nasty fall.

The safety pin (B), properly installed in the device that raises the stand into the air, will keep the stand from collapsing with you or on you.

Complete the statement below:

____ ___ will prevent injury to the user if the lifting system should fail. Injury due to falling over the edge of the stand will usually be prevented by the use of ______________________________.

Frame 49

Check the statements that are correct:

1. _____ As little as 10 milliamperes of current can be fatal.

2. _____ Watches, rings and other jewelry are shock hazards when working on electrical/electronic circuits.

3. _____ Before working on systems that employ electrical/electronic principles, you should comply with instructions given in technical orders, etc.

4. _____ Temperature and wind velocity is not a safety factor if a jet engine is not operating at maximum thrust.

5. _____ 200 feet is the minimum safe distance behind the exhaust of a jet where blast deflectors are used.

6. _____ The minimum safe distance to be in front of an operating jet engine is 5 feet.

7. _____ You will NEVER work around a jet engine while it is operating (running).

8. _____ The tips of propellers are painted yellow so they may be seen while spinning.

9. _____ Safety pins should be installed in any ejection seat system before entering the cockpit to work.

10. _____ Handrails properly installed on a maintenance stand will prevent the device that raises the stand into the air from collapsing.

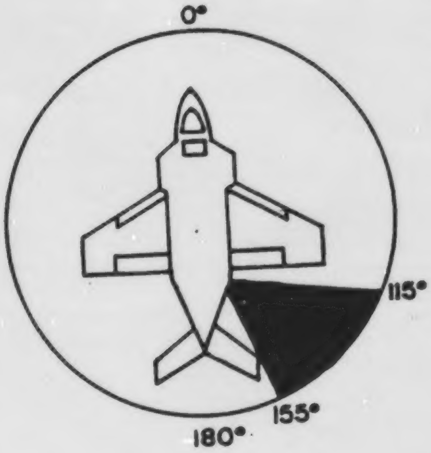
11. _____ The main reason for removing a wrist watch while working on electrical/electronic circuits is to prevent magnetic damage to the watch.

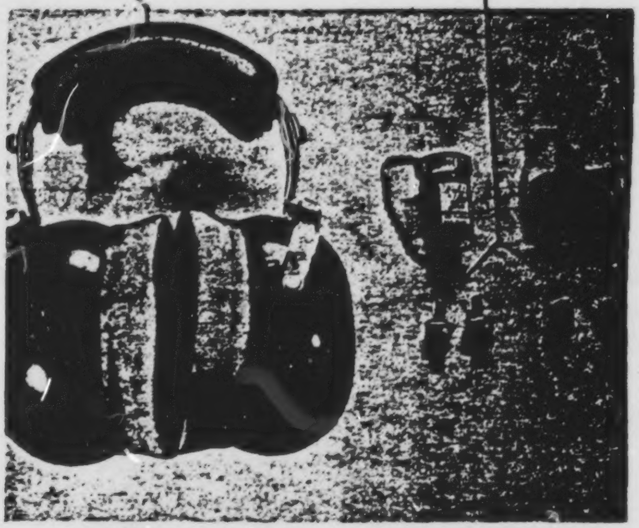
Answer to frame 48:

safety pins handrails.

Frame 50

Noise on the flight line is an ever present danger. If not respected, it can cause serious damage to your hearing; sometimes even deafness. The presence of extremely loud noise can interfere with speech communications, hearing, and cause mental and physical "FATIGUE" which in turn can jeopardize your job performance. The Air Force recognizes the seriousness of this hazard, and issues earmuffs and earplugs which must be used when in high intensity noise areas. These devices offer the protection needed while performing your job. The three things that determine the effect noise has on the ears are, intensity, frequency, and duration. The intensity is the greatest at 115° to 155° to the rear of the nose of the aircraft. The unit of measurement of sound (noise) is the "Decible."





Types of ear protectors (defenders)

Check the correct statement(s):

1. _____ Ear protectors should be worn at all times in high intensity noise areas.

2. _____ Wearing earplugs alone offers as much protection as using both muffs and plugs together.

3. _____ Loud noise can cause mental fatigue.

4. _____ Noise intensity is the greatest at 115° to 155° to the rear of the nose of the aircraft.

Answer to frame 49:

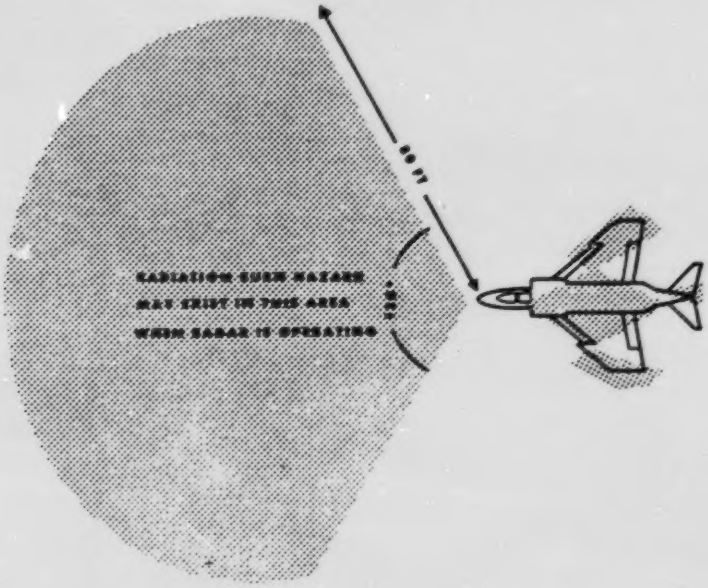
1. ✓ 2. ✓ 3. ✓ 4. _____ 5. _____ 6. _____ 7. _____

8. ✓ 9. ✓ 10. _____ 11. _____

Frame 51

While we are on the subject of sounds and injury, there are sounds above our ability to hear. These are called radio frequency transmissions (electromagnetic radiation is another common expression for it). This radiation is given off by high frequency transmitters (antennaes), such as Radar and Electronic Counter Measure Devices. The source of this hazard is often hidden behind the nose cone of an aircraft; therefore, we may come unsuspectingly in contact with it. The terrific energy radiated by these antennae can cause burns beneath the skin, cataracts over the eyes, and can even cause flash bulbs to ignite and steel wool to burn. The presence of this energy, since it is invisible, may not be readily apparent since burns will result before the pain is felt.

> Note: Radiation occurs only along a line directly in front of the antenna; however, some antennae swing in an arc or a circle. For the minimum safe distance, applicable aircraft technical orders should be referred to as the distance will vary from aircraft to aircraft due to the type of systems installed.



The best protection against this unseen menace is to know about the effects of high frequency electromagnetic radiation and to steer clear of aircraft and fixed antennae that are in operation.

Check the correct statement(s):

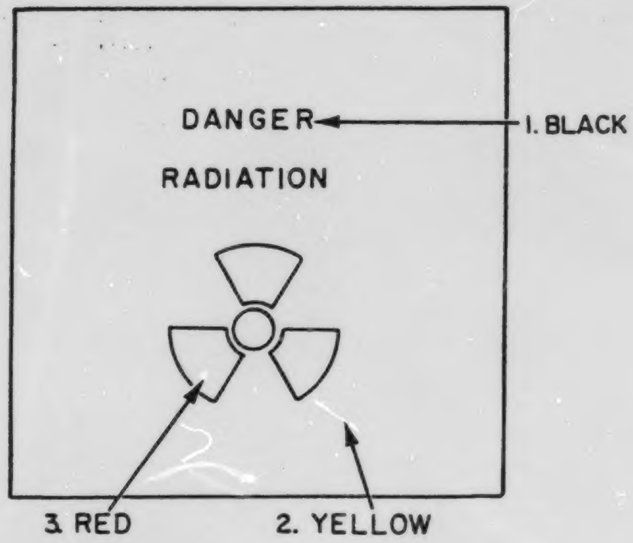
1. _____ Electromagnetic radiation can be seen.
2. _____ Operating transmitters are readily visible.
3. _____ Know the minimum safe distance and you will not be injured.

Answers to frame 50:

1._✓_ 2._____ 3._✓_ 4._✓_

Frame 52

Nuclear (atomic) radiation is probably the least likely hazard to be encountered on the flight line. It might exist, however, in the event an accident should occur while handling one of these weapons or if an aircraft carrying one of them should crash. Then, too, one of our planes may fly through a contaminated zone; and upon its return, require maintenance on one of our systems. However, under normal circumstances, the aircraft will be decontaminated (washed down with soap and water) by the flight line crews before any maintenance is performed. Radiation can be emitted from many other sources, but all sources will be marked by the Radiation Placard shown below. Materials that are radioactive will be so marked that the symbol can be seen from any direction of approach. Study the symbol; its shape and colors.



This symbol appears on AFTO Form 9 and 9 series "B" through "F," and warns personnel of radiation and radioactive hazardous areas or materials.

Check the correct statement(s):

1. ____ If you see the above symbol, but haven't heard an explosion, it is safe to disregard it.

2. ____ AFTO Form 9 warns us of hazards due to high frequency noise.

3. ____ AFTO Form 9 has a red background.

4. ____ AFTO Form 9 series warns us of radioactivity and radiation hazards.

Answer to frame 51:

1.____ 2.____ 3.__✓__

218

Frame 53

If you should work on or be near contaminated equipment, you will be under the supervision of medical personnel and a monitoring team. In addition, you must wear a film badge or "dosimeter" so the amount of radiation (dosage) you have received can be measured and put in your medical records. You will not be allowed to accumulate too many "Roentgens." The roentgen is the unit of measurement of radioactivity.

Complete the following statement:

Radiation dosage is measured by a______ ___________ or ____________ and is expressed in units of measurement called_______________________.

Answer to frame 52:

1._____ 2._____ 3._____ 4._✓__

Frame 54

Cigarettes, cokes, candy, etc, will not be carried or consumed while in a contaminated area. After working in or around a contaminated area, you will shower and be checked to see if you have removed all the radiation particles. If you are completely free of them, you will dress in clean, contamination free clothing. Any waste materials from the cleaning, let's say, from a contaminated aircraft will be disposed of by burial downwind from the maintenance activity. Parts that are radioactive will be marked (Frame 52) with one of the AFTO Form 9 series.

Match the terms in column A to the terms in column B by placing the number in the space provided.

Column A		Column B
1. Radiation placard	______a.	Method of disposing of contaminated waste.
2. Roentgen	______b.	Not allowed in contaminated areas.
3. Burying	______c.	Measures radiation dosage.
4. Dosimeter	______d.	AFTO Form 9.
5. Smoking	______e.	Unit of measurement.

Answers to frame 53:

Film badge or dosimeter Roentgens

220

This completes the programmed text on safety. Ask your instructor for the test on the safety information you have just completed.

Answers to frame 54:

3 a. 5 b. 4 c. 1 d. 2 e.

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ATC 74-27002

212

PROGRAMMED TEXT
3ABR32530-1-PT-105
3ABR32531-PT-105
3ABR32632B-PT-204

Technical Training

Avionics Instrument Systems Specialist
Automatic Flight Control System Specialist
Integrated Avionics Systems Specialist

MAINTENANCE FUNDAMENTALS

7 October 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3360th Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.
DO NOT USE ON THE JOB.

FOREWORD

This programmed text was prepared for use in the 3ABR32531, 3ABR32530-1, and 3ABR32632B courses. It was validated using 37 students from the respective courses. Average time to complete this text is 56 minutes.

OBJECTIVES

1. Without reference, identify facts concerning maintenance fundamentals. An accuracy of 75% is required.

    a. Protecting exposed electrical connectors and open pressure lines.

    b. Removing and installing components.

    c. Controlling corrosion.

This programmed text presents information in small steps called "frames." After each frame you are to make a response by circling the letter of the correct statement(s). Check the accuracy of your work by comparing your answer(s) with the correct answer(s) given at the bottom of the following page. If you make an incorrect response, correct your error before continuing to the next frame. READ THE MATERIAL CAREFULLY AND DO NOT HURRY!

Supersedes 3ABR32530-1-PT-116, 5 June 1973; 3ABR32632B-PT-213A and 3ABR32530-1-PT-111C, 6 November 1975; 3ABR32531-PT-106, 3ABR32632B-PT-210, 21 October 1974.
OPR: TTMCW
DISTRIBUTION: X
TTMCW - 200; TTS - 1

As an instrument mechanic, you will remove and install instruments. When you remove an instrument from an aircraft, lines and electrical connectors will be plugged or capped. This keeps dirt, moisture, and other foreign matter out. If an instrument is removed from an aircraft, handle it with care for it is a delicate item. You should know the different types of instrument mounts. The two types of instrument mounts are the bezel and clamp. Both types of mounts may be found on some instrument panels.

Circle the letter of the correct statement(s).

a. Lines and electrical connectors will be capped or plugged when instruments are removed from the aircraft.

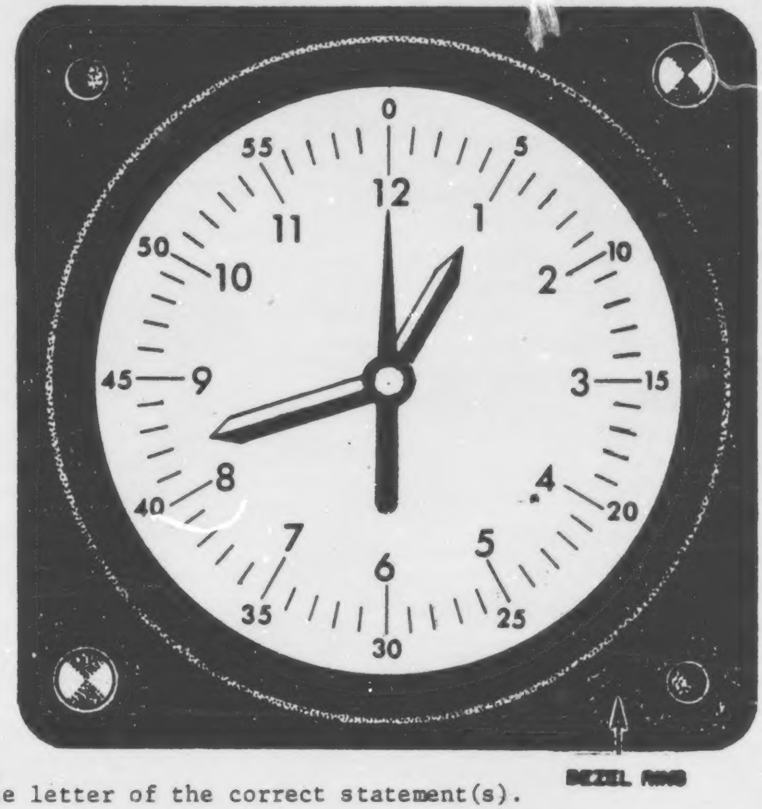
b. The different types of instrument mounts will never be found on the same instrument panel.

c. "Bezel" and "Clamp" are the two types of instrument mounts.

d. All instruments should be handled with care.

Frame 2

The bezel of an instrument is a flange which holds the glass in place. See the illustration below. Depending on the instrument, the bezel will contain from two to four holes for mounting instruments in the panel. When a bezel type mounting is used, the instrument may be mounted either from the front or the rear of the panel.



Circle the letter of the correct statement(s).

a. The bezel is a flange that holds the glass of an instrument in place.

b. With the bezel type mount, instruments may be mounted from the front only.

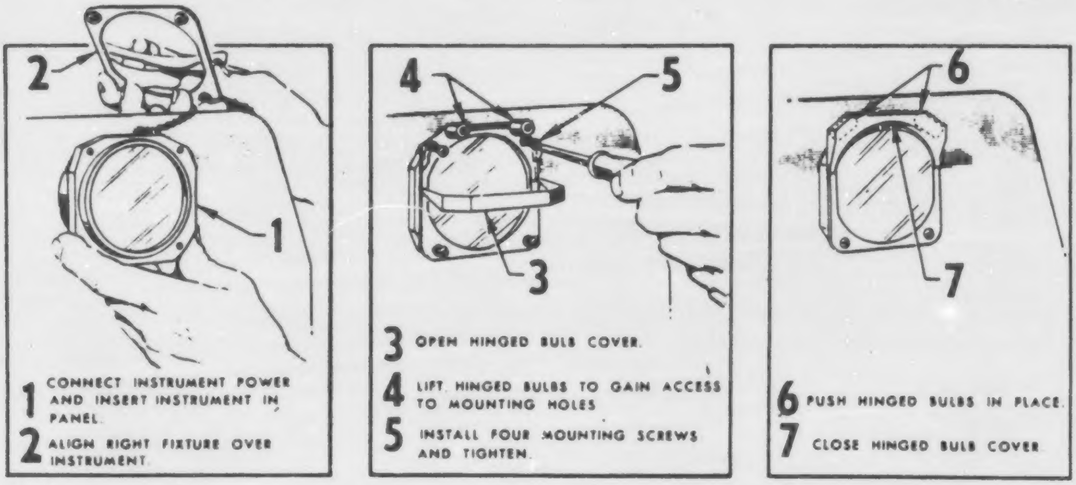
c. A bezel type mount may have two, three or four holes for mounting an instrument in the panel.

Answers to frame 1: a c d

Frame 3

Front mounting makes the instrument easier to remove and install. The front method of bezel mounting is most frequently used. In this method of mounting, connections to the instrument are made before inserting it in the panel cutout; then the instrument is inserted in the panel so that the bezel is on the cockpit side of the panel and fastened in place with mounting screws. (See illustration below.) Of course the reverse procedure would be used when removing the instrument.

Note: The standard size screws used for bezel mounting are brass (non-magnetic) round head or flat head machine screws size 6-32, or brass round head machine screws size 10-32 that are used for larger and heavier instruments such as gyros.


2
1
1 CONNECT INSTRUMENT POWER AND INSERT INSTRUMENT IN PANEL.
2 ALIGN RIGHT FIXTURE OVER INSTRUMENT.
4
5
3
3 OPEN HINGED BULB COVER.
4 LIFT HINGED BULBS TO GAIN ACCESS TO MOUNTING HOLES.
5 INSTALL FOUR MOUNTING SCREWS AND TIGHTEN.
6
7
6 PUSH HINGED BULBS IN PLACE.
7 CLOSE HINGED BULB COVER.

Front Bezel Mounting of Instruments

Circle the letter of the correct statement(s).

a. Front mounted instruments are difficult to remove or install.

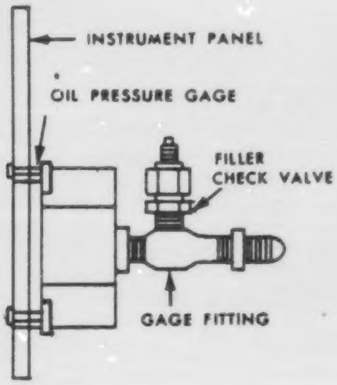
b. Connections to the instrument are made before the instrument is installed in the panel.

c. For the heavier instruments, such as gyros, steel round head screws size 10-32 are used for mounting.

Answers to frame 2: a c

Frame 4

Rear mounting, as shown below, is seldom used. The instrument is placed in the cutout from the back of the panel, and the mounting screws are inserted from the front. This method almost always requires two men; one to hold the instrument in place behind the panel, while the second man applies the screws from the front.



Rear Bezel Mounted Instrument

Circle the letter of the correct statement(s).

a. Rear mounting of an instrument, in most instances, can be easily done by one person.

b. Mounting screws are made of brass and are inserted from the rear of the instrument.

c. Instruments are seldom rear mounted.

Answer to frame 3: b

Frame 6

Some instruments are designed to be bezel or clamp mounted. When clamp mounting is desired, the bezel ring is removed (Figure A). A clamp, attached to the panel (Figure B), holds the instrument instead of the bezel.

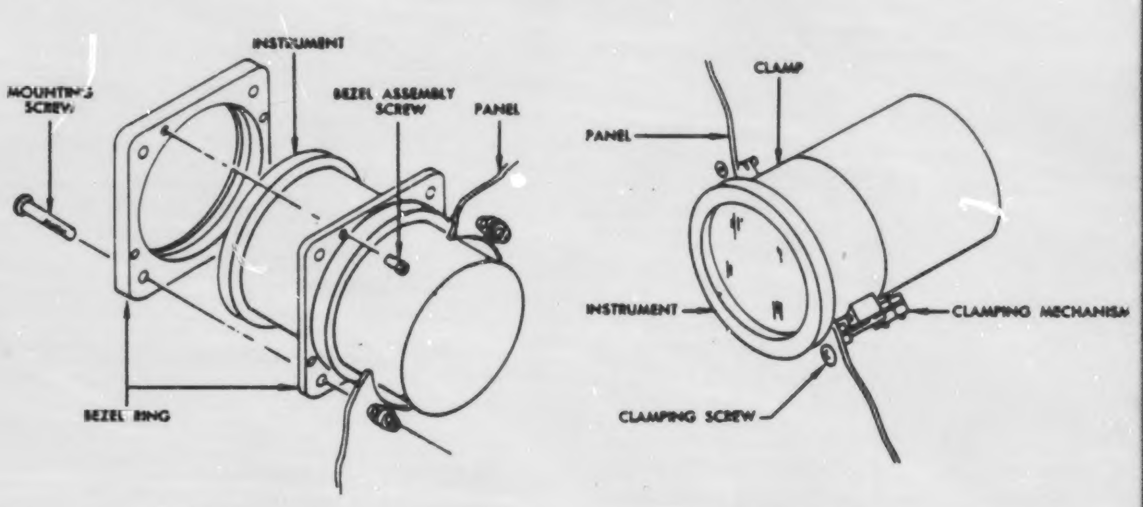

INSTRUMENT
MOUNTING SCREW
BEZEL ASSEMBLY SCREW
PANEL
BEZEL RING
CLAMP
PANEL
INSTRUMENT
CLAMPING MECHANISM
CLAMPING SCREW

Figure A

Figure B

Instrument Prepared for Clamp Mounting

Circle the letter of the correct statement(s).

a. Some instruments can be clamp or bezel mounted.

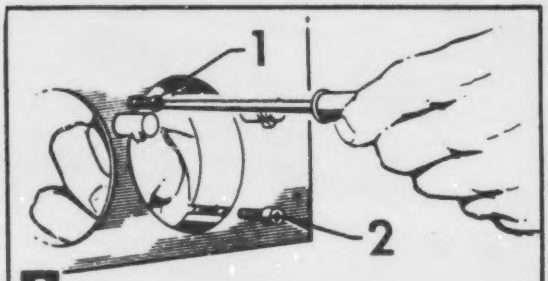
b. The two parts of the bezel ring are held together by the bezel assembly screws.

c. To change from a clamp to a bezel type of mount, the bezel is attached to the panel and not to the instrument.

Answer to frame 4: c

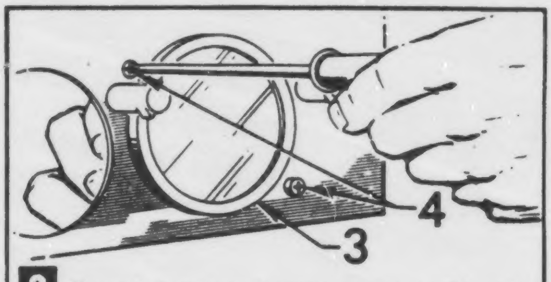
Frame 6

The clamp (see figures below) is mounted in back of the panel by one screw (1) in the upper left corner of the panel cutout. The clamping screw (2) actuates a clamping mechanism (see frame 5, figure B). One advantage of this type of mount is that the removal and installation of instruments can be done by one person in a fraction of the time, as compared to bezel type mounts. Another advantage is that, after installation, instruments can be turned in the panel so that, all pointers will be aligned.



1 Install upper left mounting screw.

2 Install lower right clump screw-jack screw.



3 Connect instrument power source and insert instrument in panel.

4 Tighten both screws.

Circle the letter of the correct statement(s).

a. There are advantages of the clamp mount over the bezel mount.

b. The clamp is mounted to the front of the panel.

c. The screw in the upper left corner of the panel cutout holds the clamp in the panel.

Answers to frame 5: a b

Frame 7

Certain items of Air Force equipment must be packaged and/or labeled when being prepared for shipment or storage. The 00-85 series Technical Orders specify Protective Packing (containers) and Preservation Packaging (cushioning or wrapping). When preparing equipment for packaging, precautions should be taken against corrosion or improper handling (dropping, etc).

Circle the letter of the correct statement(s).

a. Packing and/or labeling of Air Force equipment are for purposes of shipment and storage of the equipment only.

b. The 00-85 series Technical Orders provide specific information on Preservation Packaging.

c. During the packaging of a component you should be concerned only with protecting the component from physical damage if it is dropped or roughly handled.

Answers to frame 6: a c

Frame 8

A component is packed tightly with tissue paper, felt, glass wool, Kimpac, or sponge rubber to provide physical protection. All openings and electrical receptacles (connectors) should have a plug or cover placed over them before the component is wrapped and packed. Components with caging or locking devices will be caged or locked prior to packaging. The container used will depend on the item that is being packaged. Some components require metal containers, other items need only a wood or cardboard container. The size of the container may range from a size small enough for an aircraft clock to one large enough to package an aircraft engine. Regardless of the container and size used, only one component may be packaged in a single container.

Circle the letter of the correct statement(s).

a. Types of packing material are tissue paper, metal, glass wool, wood and sponge rubber.

b. The type of material used in the container will depend on the item being packaged.

c. All components require metal containers.

d. Openings and electrical connectors on components should be capped or plugged before packaging.

Answers to frame 7: a b

Frame 9

To provide protection against corrosion, the component is packaged in a water-vapor proof container. The enclosed air is dried by desiccant (a dehydrating agent) to a relative humidity of 20% or lower. By controlling the atmospheric humidity surrounding the component, corrosion will not occur in the shipment and storage of these expensive, complicated assemblies.

Circle the letter of the correct statement(s).

a. The enclosed air in a water-vapor container is dried by a dehydrating agent.

b. A component could become inoperative because of a small amount of corrosion.

c. The desiccant controls the relative humidity and temperature inside the container.

Answers to frame 8: b d

Frame 10

Most component packages must be opened periodically and checked for moisture. Humidity cards will indicate the presence of excessive moisture inside each water-vapor proof container. These cards have blue dots which turn pink if the package contains moisture. If the blue dots turn pink, the instrument must be bench checked and repacked along with a new desiccant into the container. The intervals at which the inspection is made depends on the level of packaging and the type of container (packing) used.

Note: The levels of packaging and packing are determined by the cushioning and material of the container. (TO 5-1-1).

Circle the letter of the correct statement(s).

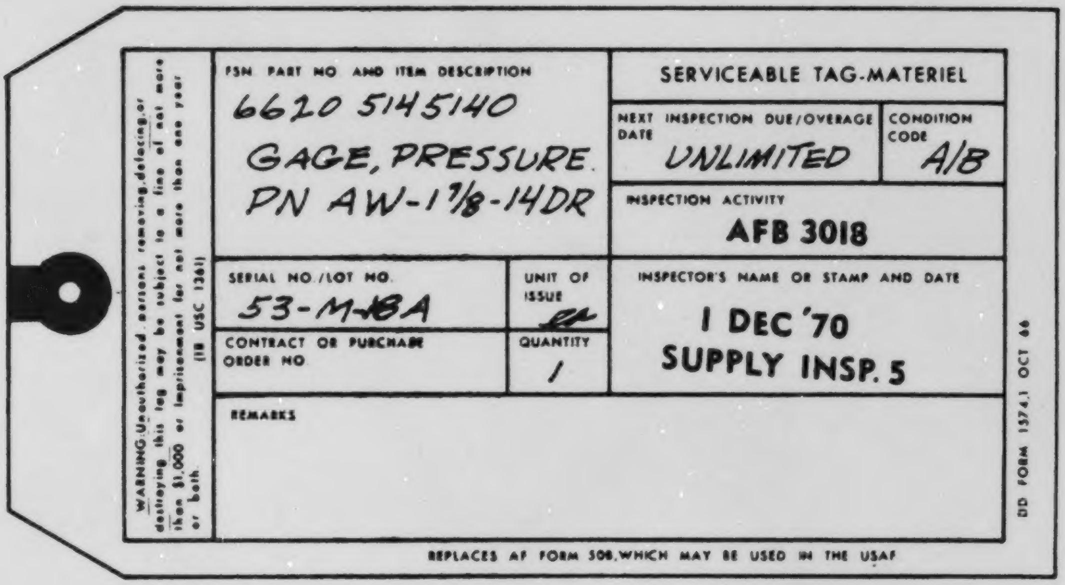
a. Humidity indicator cards are used to dry the air in water-vapor proof containers.

b. When exposed to excessive moisture, the dots on the humidity indicator card change from blue to pink.

c. All components, regardless of the container or packaging, will be checked at certain intervals when stored.

Answers to frame 9: a b

Some components, due to their types, packaging, etc. are not required to be checked after an interval of storage time (00-20K-series TOs). See status tag below.



WARNING: Unauthorized persons removing, defacing, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)

FSN PART NO AND ITEM DESCRIPTION
6620 5145140
GAGE, PRESSURE
PN AW-1 7/8-14DR

SERVICEABLE TAG-MATERIEL

NEXT INSPECTION DUE/OVERAGE DATE: UNLIMITED

CONDITION CODE: A/B

INSPECTION ACTIVITY: AFB 3018

SERIAL NO./LOT NO.: 53-M-18A

UNIT OF ISSUE: ea

CONTRACT OR PURCHASE ORDER NO:

QUANTITY: 1

INSPECTOR'S NAME OR STAMP AND DATE
1 DEC '70
SUPPLY INSP. 5

REMARKS:

DD FORM 1574.1 OCT 66

REPLACES AF FORM 508, WHICH MAY BE USED IN THE USAF

The tag would normally be on the inside of the container and the label (gummed-back counterpart of the tag) would be on the outside with the same information as listed on the tag.

Circle the letter of the correct statement(s).

a. Some components are not checked after an interval of storage time.

b. The status tag will normally be on the outside of the container.

c. The label is the counterpart of the tag and has a gummed-back.

Answers to frame 10: b

Frame 12

Activities packaging components will comply with "Marking Requirement" as listed in TO 5-1-1, Inspection, Maintenance, Storage and Shipment----etc. Some markings and labels are located as follows:

a. Status Label - On the outside of the container with the same information as the status tag (frame 22). The levels of packaging and the levels of packing in the "condition code" block will be listed on the status label for "Serviceable Items" only.

b. The marking, "Fragile Components - Handle with Care," may be labeled or stenciled on the shipping container.

c. "Re-usable container -- Do Not Destroy" is stenciled on the side of some containers.

Circle the letter of the correct statement(s).

a. Levels of packaging and packing are not required on status labels for repairable items.

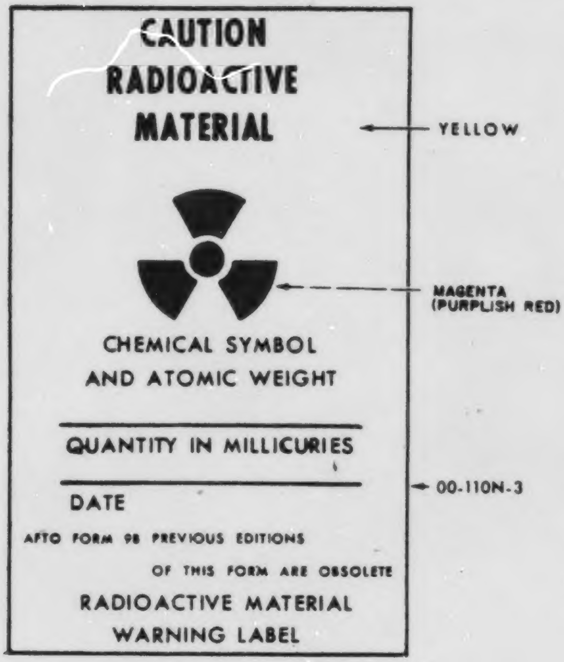
b. The status label will be inside of the shipping container.

c. The levels of packaging and packing will not be listed in the "condition code" block on the status label for repairables.

Answers to frame 11: a c

Frame 13

Components that have radioactive characteristics will be shielded, packaged or otherwise protected (AFM 71-4), and marked with an AFTO Form 9B, Radioactive Material Symbol which is shown below. The information in the lower portion of the form shall be entered on at least one label per package (TO 00-110N series). This form is not required on the outside of the container if the labeling requirements of the transportation directives are satisfied.



CAUTION
RADIOACTIVE
MATERIAL

CHEMICAL SYMBOL
AND ATOMIC WEIGHT

QUANTITY IN MILLICURIES

DATE

AFTO FORM 9B PREVIOUS EDITIONS
OF THIS FORM ARE OBSOLETE

RADIOACTIVE MATERIAL
WARNING LABEL

YELLOW
MAGENTA
(PURPLISH RED)
00-110N-3

Circle the letter of the correct statement(s).

a. An AFTO Form 9B is required on the outside of the shipping container for radioactive parts.

b. The AFTO Form 9B symbol warns of radioactivity danger.

Answers to frame 12: a c

Frame 14

A good rule to follow for packing, packaging, and repacking of components is to use the same container the serviceable part came in. Most component overhaul TOs will give a step-by-step procedure for packing and packaging of components. The following packing procedure is an example taken from TO 5E6-3-21-3, Overhaul, Electrical Resistance Thermometer.

a. Pack in reusable Nr 10 can. Insert a layer of Kimpac in bottom of can.

b. Completely line the inside of the can with a roll of Kimpac.

c. Surround the thermometer (Ratiometer) with a roll of Kimpac.

d. Place indicator in can so that it is held firmly in place.

e. Place a four ounce bag of silica gel (desiccant) on top layer of Kimpac.

f. Place cover on can and seal with ring clamp.

Note: To prevent damage to jewels and pivots, NEVER ship a ratiometer unless it has a minimum of three inches of cushioning material on all sides.

No Response Required

32632B students skip to Frame 31.

Answers to frame 13: b

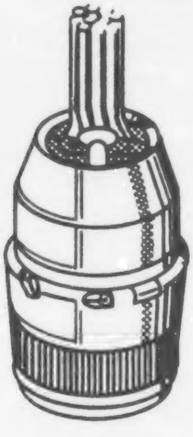
Frame 15

We have covered many aspects of component maintenance thus far, but one important area of maintenance, potting of electrical connectors located in various places in the aircraft, needs to be presented.

No Response Required

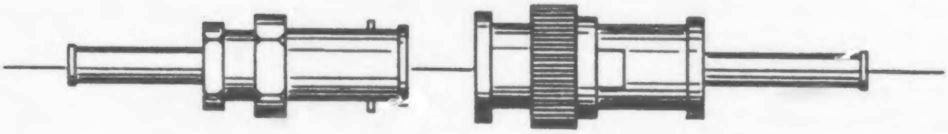
Frame 16

Some electrical connectors on aircraft must be sealed (potted) while other connectors in the same area are never potted. For instance, in the wheel-wells of B-52 aircraft, the oleo connectors (figure A) are required to be potted while coaxial cable connectors (figure B) are never potted. A good rule to follow is that if a connector in a system was potted before you worked on the system, make sure it is potted after you finish working on the system.



A.

NO RESPONSE REQUIRED



B

No Response Required

Sealing compound (potting) is used to moisture-proof the wiring connected to the backs of electrical connectors. It is also used to reinforce the backs of connectors against failure caused by vibration and lateral pressure (pull of wores) which fatigue the wires at the solder cups (pins).

Circle the correct answer(s).

Electrical connectors are potted to

a. mosture-proof the back of the connector.

b. prevent vibration of the connectr.

c. reinforce the wires at the back of the connectr.

d. cause vibration and fatigue of wires at solder cups.

Frame 18

The potting compound also protects electrical connectors from corrosion or contamination by keeping out metallic particles and aircraft liquids. It also reduces the probability of arc-over between pins on the back of the connectors. Therefore, work required on potted connectors is less frequent than on other connectors.

Circle the correct answer(s).

The potting compound in the back of electrical connectors

a. will probably cause arc-over between pins.

b. protects against corrosion and contamination.

c. keeps out aircraft liquids and metallic particles.

d. in time, will require more work on the potted connector than one not potted.

Answers to frame 17: a c

241

The location of connectors will be a factor in determining what type of potting compound to use. Some potting compounds are to be used where the temperature is very high, while other compounds are to be used where the temperature is below 200°F. Due to the number of compounds and the differences in each, we will not attempt to cover "Preparation and Application of Potting Connectors." However, before using any type of potting compound be sure to read the directions on the container and TO 1-1A-14.

In addition to the compound mixing instructions the following information may also be listed.

Warning

(1) The acceleration mixture contains a lead compound. Avoid excessive skin contact and clean hands thoroughly after handling.

(2) Observe adequate ventilation and fire precautions during mixing and storage.

Note: Complete potting within two hours after cleaning connector.

Circle the letter(s) of the correct answer(s) below.

a. Temperature at the connector's location should be known before potting is attempted.

b. The temperature range of potting compound is not important.

c. Directions on the potting container should be read and followed.

Answers to frame 18: b c .

Frame 20

The correct answers will be listed after the last review question.

Circle the correct answer below.

1. The two types of instrument mounts in use are

   a. front and rear.
   b. clamp and rear.
   c. bezel and clamp.

2. When a component is removed from the aircraft for any length of time,

   a. lines and connectors will be capped and plugged.
   b. the component will be bench checked before it is installed on the aircraft.
   c. the component will be packaged and labeled.

3. The bezel-front method of mounting can be accomplished easily

   a. if two men perform the job.
   b. by one man.
   c. by one man behind the instrument panel.

4. The levels of packaging and packing are determined by the type of

   a. cushioning material.
   b. shipping container.
   c. cushioning and the type of shipping container used.

5. Some packaging materials are

   a. Kimpac, glass-wool and felt.
   b. sponge rubber, wood and tissue paper.
   c. felt, tissue paper and metal.

6. Shipping containers can be made of

   a. wood.
   b. cardboard.
   c. wood, cardboard and metal.

7. Some labels or markings found on the outside of the shipping container are

   a. "Re-usable container" and AFTO Form 9B.
   b. "Fragile-Handle with Care" and a status label.
   c. status tag and "Warning-Radioactive."

8. The best rule to follow for packing and packaging of a repairable component is to

a. make sure you use a size 10 can or larger.
b. use the same container that the serviceable item came in if possible.
c. use sufficient packaging and a humidity indicator card.

9. Aircraft connectors are potted to

a. guard against electrical induction.
b. reduce pressure loss at pressure bulkheads.
c. increase resistance to temperature changes.
d. moisture proof the siring connected to the backs of the connectors.

10. Before mixing potting compound, it is necessary to

a. know the temperature at the connector's location.
b. know the extent of vibration at the connector's location.
c. determine the number of coaxial cable connectors to be potted.

11. The preparation and use of potting compounds requires that care must be taken to

a. mix the compound in a plastic container.
b. provide adequate ventilation and fire protection.
c. avoid excessive skin contact and to clean hands after use due to the abrasive qualities of the mixture.
d. complete the potting within 1 hour after cleaning the connector.

Answers to frame 19: a c

Frame 21

When your shop chief assigns you a work order the first thing you should do is check the aircraft forms. There may be information on the forms that is pertinent to the malfunction indicated on your work order. An operational check of the system should then be performed to see if the malfunction can be duplicated. (You may not be able to duplicate the malfunction.)

Before engaging the autopilot for an operational check (any ground operation) be sure that other personnel are not working on or around the aircraft control surfaces, spoilers, control cables, or actuators. The operational check could result in sudden movement of these controls and could cause injury to other personnel.

Place a (T) for True and an (F) for False in the spaces provided below.

____ 1. The aircraft forms may contain useable information that is not on the work order.

____ 2. An operational check is not necessary because the work order will tell you all you need to know.

____ 3. You should know the location of other personnel on the aircraft before performing an operational check.

Answers to frame 20: 1. c 2. a 3. b 4. c 5. a

6. c 7. b 8. b 9. d 10. a 11. b

Frame 22

After an operational check of the system you should be able to isolate the cause of the malfunction to a certain area of the system. Then by troubleshooting you should be able to determine the cause of the malfunction. If you determine that a component has to be removed, repaired, or replaced, make sure that the electrical power to the component is turned off. If there are hydraulic lines connected to the component, bleed the pressure from these lines. Make sure you have the tools that will be needed to remove the components. You should have a checklist of all the tools that you take on the job and when finished check to make sure you have all your tools. A loose wrench, screwdriver, etc., can be very dangerous on an aircraft.

Place a (T) for True and an (F) for False in the spaces provided below.

____ 1. Before removing a component, the hydraulic pressure and electrical power should be turned ON.

____ 2. Troubleshooting checks should be performed to make sure that a certain component is causing the malfunction before removing the component.

____ 3. A checklist should be used to make sure that all tools are removed from the aircraft.

Answers to frame 21: 1. True 2. False 3. True

Frame 23

After determining that a component should be removed and that you have the proper tools to do the job, all safety wire (if any) should be removed from the component. All used safety wire or any unreusable item that is removed should be placed in an FOD (Foreign Object Damage) container. This prevents the possibility of loose pieces of safety wire from shorting out the electrical circuits. Pieces of safety wire or other items left on the runway could be drawn into the intake of a jet engine causing damage to the engine.

After the safety wire has been removed, the electrical connectors and hydraulic lines (if any) should be disconnected. When removing electrical connectors and hydraulic lines, both the male and female connectors should be capped. This is done to prevent damage to the connectors and to keep dirt and other foreign objects from the connectors and lines. The procedures for the final removal of each component are different and should be accomplished in accordance with (IAW) the applicable technical order.

Place a (T) for True and an (F) for False in the spaces provided below.

____ 1. All safety wire that has been removed should be placed in an FOD container.

____ 2. When disconnected, hydraulic lines and electrical connectors should be capped.

____ 3. Removal of a component should be done IAW the TO for that system.

Answers to frame 22. 1. False 2. True 3. True

Frame 24

When installing a new component or reinstalling one that was removed and repaired, remove the protective caps from the electrical connectors and hydraulic lines (8f any). Attach and safety wire (when necessary) the electrical connectors and hydraulic lines. Install the component using the applicable technical order. Make sure that all mounting screws, nuts, or bolts are tight and safety wired. When the installation is completed, apply electrical power and hydraulic pressure (if needed) and operational check the system IAW the applicable TO. If the system checks OK, the aircraft forms are signed off and the job is completed.

Place a (T) for True and an (F) for False in the spaces provided below.

____ 1. When you have installed the component your job is completed.

____ 2. A component that was safety wired when removed does not have to be reqired after replacement.

____ 3. Components should be removed and installed IAW the applicable technical order.

____ 4. After installing a component, an operational check of the system must be performed.

____ 5. Aircraft forms must be signed off after replacing a component.

Answers to frame 23: 1. True 2. True 3. True

Frame 25

At one time or another, corrosion becomes a problem for just about everyone. Has your car ever failed to start because the battery cables were corroded? What about the door you couldn't open because the hinges or lock had rusted? And that car you wanted to buy would have been just perfect--had not the fenders been rusted so badly. Sound familiar? They probably do because corrosion always seems to be at work somewhere.

Just like everyone else, the Air Force has a problem with corrosion. But considering the size of the Air Force and the amount of equipment it must maintain, you can imagine just how large that problem is. In fact, the cost of fighting corrosion runs into millions of dollars every year.

But don't think of it as the Air Force's problem because you are the Air Force, no less than anyone else who wears the uniform. Like most other problems, corrosion cannot be handled without your help. However, before you can help, you will have to know exactly what it is and your responsibilities in its prevention and control.

NO RESPONSE REQUIRED

Answers to frame 24: 1. False 2. False 3. True 4. True 5. True

Frame 26

First of all, corrosion is defined as the deterioration of a metal by reaction to its environment. If you prefer simpler definitions, it's similar to the old theory of what goes up must come down. Since most metals are manufactured by a chemical process, they have a tendency to return to their original, natural state. This process of returning is called corrosion. (Some metals, such as gold and platinum, are not affected by corrosion because they are still in their natural state.)

Check (✓) the true statement(s) below.

_____1. All metals are subject to corrosion.

_____2. Corrosion causes metal to return to its natural state.

Answer to frame 25: NO RESPONSE REQUIRED.

Frame 27

Although there are several different types of corrosion, we will only discuss one type in this PT - electrochemical corrosion. It deteriorates the metal quickly and does far more damage than any other type. In fact, most of the other types merely lead to electrochemical corrosion. Now let's see how it works....

"Electro" represents electricity: the flow of electrons from one point to another. In turn, the difference in "chemical" makeup between two points creates the potential for electron flow. In other words, electrons flow from a place that has a surplus of electrons to a place that has a shortage of electrons (you should remember this from Electronic Principles). Corrosion occurs in the place that is losing electrons.

These places can either be two pieces of metal in contact with each other or two areas in the same piece of metal.

Check (✓) the true statement(s) below:

_____1. Electrochemical is the most serious type of corrosion.

_____2. The chemical makeup of a piece of metal can vary from place to place in that piece of metal.

_____3. Corrosion occurs in the place that is gaining electrons.

Answers to frame 26: _____ 1. __✓__ 2.

So now you have all the requirements for corrosion, right? Wrong! Think back to Electronic Principles again. Perhaps you remember that there must be a complete path or circuit before the electrons can flow. The metal itself provides half of that circuit, but the other half is provided by contamination on the surface. (See figure 1.)

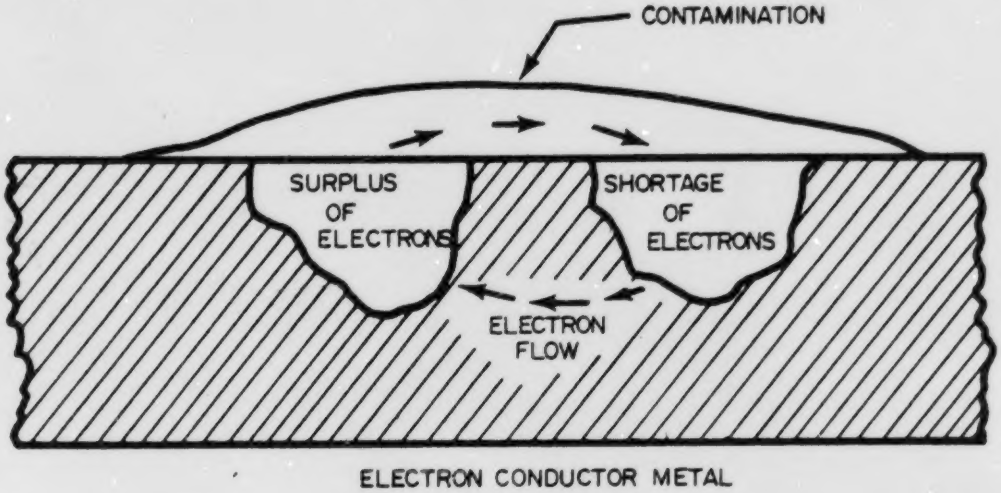


Figure 1. Metal and Contamination Form Circuit for Electron Flow.

Often this contamination is moisture, but other contaminants like salt, dirt, and excessive grease or oil tend to attract moisture and then lead to the same result. Hold it!! Are you thinking that grease and oil would be more likely to protect the metal than lead to corrosion? That's true up to a point. But if they are applied excessively, they collect dirt which in turn collects moisture. See the connection?

Metal shavings can also act as conductors for the electrons, just as moisture does. They should also be considered a form of contamination.

Check (✓) the true statement(s) below.

_____1. Contamination does not need to be present for corrosion to begin.

_____2. Moisture is the only form of contamination.

_____3. Contamination provides a complete circuit for electron flow.

Answers to frame 27: __✓__ 1. __✓__ 2. _____ 3.

252

Frame 29

So far you've learned the two basic causes of corrosion: a difference in chemical makeup and contamination. Both are directly involved with the electrochemical process, and both must be present for corrosion to begin. Now, if you have all that straight, let's go on to some other factors.

NO RESPONSE REQUIRED

Answers to frame 28: ____ 1. ____ 2. _✓_ 3.

Stress is any force applied to metal. It's not actually a cause of corrosion, but the weakening effect it has on metal can lead to corrosion. Given time, and if the stress is great enough, it can crack thin metals, especially along welded seams and around riveted and bolted joints.

Although this sort of structural damage is extremely dangerous in itself, it is by no means the worst that can happen. Since the cracks caused by stress are usually very small, they can easily go undetected. If so, contamination will collect in them causing corrosion to begin. In such cases, the corrosion will usually do a great amount of damage in a short period of time. This is because the cracks have already penetrated any type of protective coating on the surface (paint, etc). Therefore, corrosion is free to attack the core of the metal.

Some sources of stress are expansion and contraction due to temperature changes and vibration due to operation of equipment.

It's important to realize that stress does not take an active part in the corrosive process. Instead, it gives corrosion a place to begin--a foothold so to speak.

Check (✓) the true statement(s) below.

_____1. Stress weakens metal.

_____2. Cracks caused by stress are not important because they will not penetrate the protective coating on the surface.

_____3. Structural damage caused by stress is usually found along welded seams and around riveted and bolted joints.

_____4. Corrosion cannot take place without stress damage.

Answer to frame 29: NO RESPONSE REQUIRED.

Frame 31

Next, let's talk about geographical location as a factor in corrosion. Some geographical locations contain more sources of contamination than others - it's as simple as that. As an obvious example, metal located on a semi-tropical coastline such as Florida would be exposed to much more salt and moisture than metal located in the Arizona desert. Therefore, you can assume that corrosion prevention would be more difficult in Florida.

Check (✓) the true statement(s) below.

_____1. Geographical location has little to do with corrosion.

_____2. Some geographical locations contain more sources of contamination than others.

Answers to frame 30: ✓ 1. _____ 2. ✓ 3. _____ 4.

Frame 32

Chemical differences between metals, contamination, stress, and geographical location are all either products of or directly associated with the environment. In our case, the environment consists of the conditions or influences that surround a piece of metal.

You already know that these conditions or influences could be anything from the metal shavings a maintenance man left behind to the vibration caused by a jet engine. Therefore, it's obvious that environment is a very general term, involving a great many factors that affect the progress of corrosion. That's why it was used in the original, general definition of corrosion (the deterioration of a metal by reaction to its environment).

Check (✓) the true statement(s) below.

_____1. The conditions or influences that surround a piece of metal make up its environment.

_____2. Corrosion is the reaction of a metal to its environment.

_____3. The environment involves very few of the factors that affect corrosion.

Answers to frame 31: _____ 1. __✓__ 2.

Frame 33

Hopefully, you now have a basic understanding of how corrosion works, because understanding a problem is essential in solving it. As you've probably guessed, our next topic is corrosion prevention.

Although many methods are used to prevent corrosion, they all have one common purpose. That purpose is to stop its basic elements - the damaging flow of electrons. If you stop the electron flow, you stop corrosion.

NO RESPONSE REQUIRED

Answers to frame 32: ✓ 1. ✓ 2. _ 3.

Frame 34

First of all, let's talk about the two basic causes of the electron flow: difference in chemical makeup and contamination. If either is eliminated, corrosion will not take place.

Actually, as a maintenance specialist, you will have very little to do with eliminating the chemical differences in metal. Problems in this area are corrected (if possible) in the designing and manufacturing of the metal and the equipment it will be a part of.

However, it will be your job to remove and replace parts on aircraft. When doing so, you must be careful to install the correct part. Failure to do this may create a chemical difference between the incorrect part and the metal surrounding it. As you already know, this will cause corrosion if contamination is present. Such mistakes usually happen when installing small pieces of hardware such as screws, bolts, etc, (see figure 2).

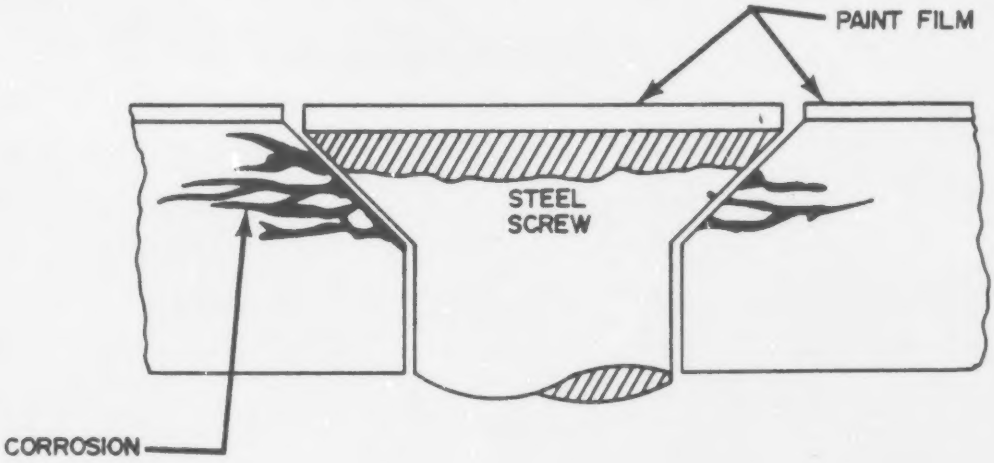


Figure 2.

Check (✓) the true statement(s) below.

_____1. If possible, equipment is designed so that metals with different chemical makeups are not in close contact with each other.

_____2. The basic rule for installing a part is: If it fits, it'll work just fine.

_____3. Corrosion will take place whether there is a difference in chemical makeup or not.

Answer to frame 33: NO RESPONSE REQUIRED.

Frame 35

Contamination is the other basic cause of corrosion and the cure for it is cleaning. Since you've been in the Air Force for some time now, you may already be familiar with it. Most of the cleaning you've done so far has probably been for reasons of health or safety. But when dealing with multi-million dollar equipment, it becomes the first line of defense against corrosion. Remember, if contamination is not present, corrosion will not take place.

Check (✓) the true statement(s) below.

_____1. Cleaning is done only for reasons of health or safety.

_____2. Corrosion will not take place unless some type of contamination is present.

_____3. Cleaning is the only method of preventing corrosion.

Answers to frame 34: __✓__ 1. _____ 2. _____ 3.

Most other methods of preventing corrosion consist of applying a protective coating to the surface of the metal. The most familiar of these methods is painting.

When paint is applied to a metal surface, it inhibits or slows down any corrosive flow of electrons that might take place. It also prevents most contaminants from reaching the metal's surface.

In spite of its value as a corrosion fighter, paint will do more harm than good if it's not applied correctly. The surface to be painted must be clean, dry, and free from corrosion. Otherwise, corrosion will be able to start or continue its destruction beneath the paint - undetected.

Check (✓) the true statement(s) below.

_____1. Paint does nothing more than improve the appearance of the metal.

_____2. Paint slows down electron flow.

_____3. Painting over corrosion will keep it from progressing.

Answers to frame 35: _____ 1. __✓__ 2. _____ 3.

Frame 37

Finally, let's take a quick look at two more methods of prevention. Some metals are specially made to resist corrosion. An example is stainless steel. It does not require painting for protection. Other metals that do not require painting are those chemically treated to resist corrosion.

Check (✓) the true statement(s) below.

_____1. Stainless steel must be painted before it will resist corrosion.

_____2. All metals are chemically treated to resist corrosion.

Answers to frame 36: _____ 1. __✓__ 2. _____ 3.

Frame 38

Unfortunately, none of these methods of preventing corrosion are foolproof. The metal might have been manufactured incorrectly or its protective coating applied poorly. Stress may create cracks in the metal and its protective coating. Perhaps the surface will not be kept thoroughly clean. The only protection against all of these possibilities is inspection.

Inspection is the act of looking over or examining. It is done in order to determine the condition of parts or equipment. By itself, inspection cannot cure anything. But on the other hand, it's impossible to correct a corrosive situation if you don't know it exists. So you can see that inspection plays an important part in preventing and controlling corrosion.

There are several types of officially-scheduled inspections for aircraft (these inspections aren't totally concerned with corrosion, many other types of problems are checked for also). You may take part in some of these. But even if you don't, make small inspections of your own. Look over the area where you are working for signs of corrosion.

Check (✓) the true statement(s) below.

_____1. Since official inspections are pulled, there's no need for you to do any inspecting on your own.

_____2. Inspections determine the condition of parts and equipment.

_____3. Inspection, by itself, doesn't stop corrosion.

Answers to frame 37: _____ 1. _____ 2.

Frame 39

When inspecting for corrosion, here are some of the signs you should look for:

In almost all metals, the first sign will be a powdery residue on the surface (aluminum is an exception--its first indication will be a dulling of the normally bright surface which will gradually develop into residue). This residue is what remains after the surplus electrons have passed out of the metal. It can be likened to the ashes that remain after a fire. Residue will be white or gray for aluminum, reddish brown for iron or steel, and green for brass or copper. If detected early in this stage, little damage will have been done other than to mar the appearance of the surface.

But if allowed to continue, the amount of residue will increase as the corrosion penetrates deeper into the metal. This penetration is called etching in its early stages, and then pitting as it gets deeper (see figure 3). Depending upon how deep it gets, pitting can be repaired. However, if not stopped, pitting will continue completely through the metal causing irreparable damage.

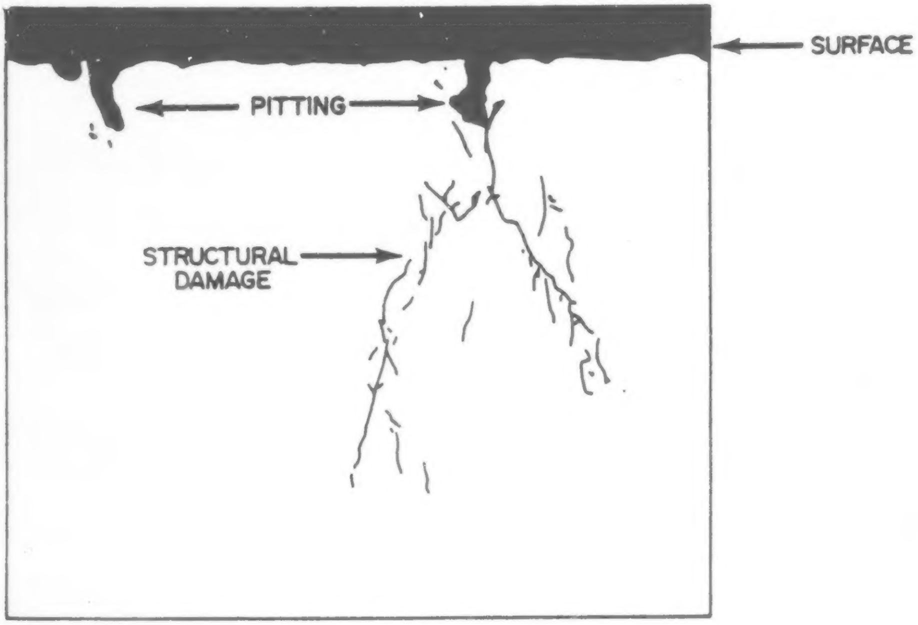


Figure 3. Cross Sectional View of Pitting and Structural Damage. In this case, structural damage resulted from the pitting action.

Answers to frame 38: _____ 1. __✓__ 2. _____ 3.

Check (✓) the true statement(s) below.

_____1. Pitting cannot be repaired, even in its early stages.

_____2. Minor penetration by corrosion is called etching.

_____3. Residue is the powdery substance that remains after electrons have passed out of the metal.

_____4. Residue on the surface of steel will be white or gray in color.

_____5. After a small amount of damage, pitting will stop by itself.

Frame 40

The last topic of this PT covers your responsibilities in helping to prevent and control corrosion. We mentioned one of them just a moment ago when talking about inspection, but it will bear repeating.

When working on aircraft, or any type of Air Force equipment for that matter, take time to inspect the immediate area. Look for signs of contamination, corrosion, and structural damage. Likely places to find contamination and/or corrosion will be in cracks and crevices where two pieces of metal are joined and in corners. In other words, hard to reach areas. Likely places to find the small cracks caused by stress will be on the surface of thin metals, along welded seams, and around joints.

Check (✓) the true statement(s) below.

_____1. Contamination will usually be found in hard to reach places such as cracks, crevices, and corners.

_____2. Structural damage is likely to be found on the surface of thin metals, along welded seams, and around joints.

Answers to frame 39: _____ 1. __✓__ 2. __✓__ 3. _____ 4. _____ 5.

Frame 41

You know that inspection by itself can't cure anything. So here's what you should do if you find any of those problems.

Remove all deposits of contamination. This will include moisture, dirt, soot, salt, metal shavings, excessive grease or oil, etc. Likewise, remove all small deposits of corrosion with steel wool, a steel brush, or a metal file. When doing so, be sure to remove the corrosion completely.

Although both of these operations may sound rather simple to you, the procedure for them can be very complex depending upon the type of metal and the type of corrosion. Therefore, refer to an appropriate technical order before cleaning a component or removing corrosion. TO 1-1-2 contains general information and instructions for every type of metal and corrosion. In addition, specific instructions for each system or component are contained in the Field Maintenance Instructions TO (-2) and Overhaul TO (-3) for that system or component.

Check (✓) the true statement(s) below.

_____1. Remove small deposits of corrosion with steel wool, a steel brush, or a metal file.

_____2. TO 1-1-2 contains specific instructions for repairing every system or component.

_____3. Field Maintenance TOs and Overhaul TOs contain specific instructions for each system or component.

Answers to frame 40: __✓__ 1. __✓__ 2.

Frame 42

On the other hand, if you find evidence of structural damage and/or severe, frequent, or unusual corrosion, do not attempt to repair it yourself. Instead, report it on the appropriate discrepancy form. For aircraft this will be the AFTO Forms 781. The title of this form is the "Aircraft Flight Report and Maintenance Record." After you report the problem, the repair work will be done by corrosion specialists.

Check (✓) the true statement(s) below.

_____1. You should repair all corrosion personally.

_____2. Report excessive corrosion and structural damage on the "Aircraft Flight Report and Maintenance Record" (AFTO Forms 781).

Answers to frame 41: __✓__ 1. _____ 2. __✓__ 3.

Perhaps you remember that cracks caused by stress are doubly dangerous because they tend to collect contamination. Well, scratches in metal surfaces also tend to collect contamination. If a scratch penetrates the protective coating (paint, etc), corrosion will be free to attack the metal. Therefore, be careful when handling tools and equipment capable of scratching metal surfaces. In the same manner, your job may require you to climb on top of an aircraft. Before doing so, check your shoes for gravel, tacks, etc, that might scratch its surface.

Finally, the least you can do is clean up after yourself before leaving the area.

Check (✓) the true statement(s) below.

_____1. Damage from any scratch is too minor to encourage corrosion.

_____2. Take your shoes off before getting on top of an aircraft.

_____3. In order to tell components apart, it's okay to mark them with a sharp object.

_____4. After completing a job, always clean up after yourself.

Answers to frame 42: _____ 1. __✓__ 2.

Frame 44

In conclusion, we can only ask you to always be aware of your responsibilities in the area of corrosion. Once again, they are cleaning, inspecting, repairing, reporting, and following TO instructions. All of this will take extra effort on your part. But isn't a pilot's life worth a little extra effort?

NO RESPONSE REQUIRED

Answers to frame 43: _____ 1. _____ 2. _____ 3. __✓__ 4.

PROGRAMMED TEXT
3ABR32530-1-PT-105A
3ABR32531-PT-105A
3ABR32632B-PT-204A

Technical Training

Automatic Flight Control Systems Specialist
Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

AIRCRAFT HARDWARE

30 November 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

270

FOREWORD

This programmed text was prepared for use in the Automatic Flight Control Systems Specialist Course 3ABR32530-1. The materials contained herein were validated with 26 students from the subject course. At least 90% of the students achieved the objectives as stated below. Average time for completion of this text is 89 minutes.

OBJECTIVES

1. Without reference, identify facts concerning maintenance fundamentals. An accuracy of 70% is required.

    a. Aircraft hardware.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Carefully study the written material and/or illustration in each frame until you are confident that you understand the contents of the frame. You will be required to respond to the information in each frame in one of a variety of ways. Follow the instructions in each frame. Check the accuracy of your response at the bottom of the next page. If any of your answers are incorrect, go over the frame until you understand why you made the error, then proceed to the next frame. Use the hardware trainer when directed, and take sufficient time to make sure that you understand each item.

READ VERY CAREFULLY AND DO NOT HURRY.

Supersedes 3ABR32530-1-PT-111, 22 May 1973.
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292

Most bolts used in aircraft structures are either general purpose, internal wrenching, or close-tolerance AN (Army-Navy), NAS (National Aircraft Standard), or MS (Military Standard) bolts. These bolts are made of aluminum alloy where lightness is needed, or of steel when strength is needed. Perhaps, before going any further, you should have an understanding of a few terms which may appear throughout this text.

Tension is the amount of clamping force developed in a bolt. It acts as a pressure on the assembly shown in B below. When a bolt is tightened, it develops a "holding together" (tension) force within the bolt and a pressure on the assembly. The greater the tension, the greater the "holding together" effect.

Stress is a force exerted upon a body that tends to strain or deform its shape.

Shearing stress is the action or force causing two contacting parts or layers to slide upon each other, moving apart in opposite directions parallel to the plane of their contact.

Tensile strength is resistance to lengthwise stress.

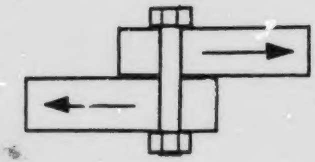
Shear strength is the opposite from tensile strength in that it is caused by a push or pull 90° from the axis; whereas, tensile strength is determined by a pull parallel to the axis.

Using the illustration below, identify the type of stress applied to each bolt.

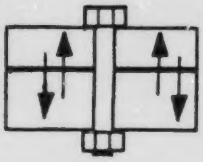
1. Tensile. __________

2. Shear. __________

A.



B.

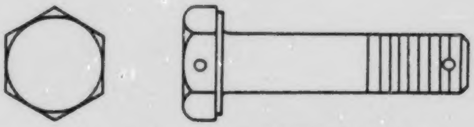


The arrows show the direction of stress.

Frame 2

Three general types of bolts are: standard aircraft bolts, clevis bolts, and eyebolts.

Standard aircraft machine bolts are all-purpose structural bolts used for general applications involving tension on shear loads. They may be either cadmium- or zinc-plated, noncorrosion resistant steel, or anodized aluminum. These bolts may not be drilled or they may have a drilled head or a drilled shank only; sometimes, both the head and shank may be drilled.



STANDARD AIRCRAFT MACHINE BOLT

Place a T for true or an F for false in the space provided.

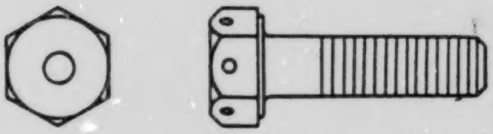
_____1. Standard aircraft bolts may only be obtained with drilled heads.

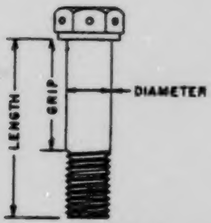
_____2. Standard aircraft bolts are used only where tension is involved.

ANSWERS TO FRAME 1: Tensile B. Shear A.

Frame 3

Drilled head bolts are similar to standard aircraft bolts except for a deeper head that is drilled to receive a wire which is used for securing. They were originally intended for use as engine bolts.





DRILLED HEAD BOLT

Study the illustrations above and become familiar with the terms used for area identification: length, grip, and diameter.

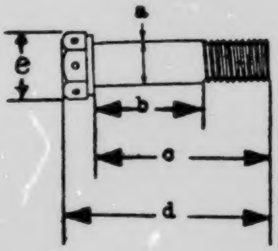
Match the letters in the illustration to the correct terms.

_____1. Diameter.

_____2. Length.

_____3. Grip.

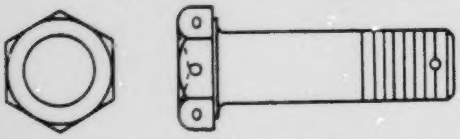
_____4. Head (Wrench Size)



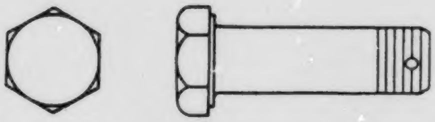
ANSWERS TO FRAME 2: __F__1. __T__2.

Frame 4

Close-tolerance hex head bolts are used where the bolted joint is subject to severe load reversals and vibration. The shank of this type of bolt has a tolerance which permits a very close fit with the use of reamers, otherwise, they are identical to the standard hex head bolts. These bolts are available as tensile bolts with drilled heads or drilled shanks and as shear bolts with or without a cotter pin hole.



HEX HEAD, CLOSE-TOLERANCE TENSILE BOLT



CLOSE-TOLERANCE SHEAR BOLT

Indicate if the following statements are TRUE or FALSE by placing a T or an F in each space provided.

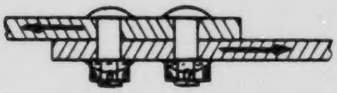
_____1. The use of close-tolerance bolts might require the use of reamers to provide a very close fit.

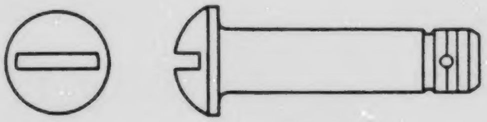
_____2. The amount of vibration is not a determinant in using a close-tolerance bolt.

ANSWERS TO FRAME 3: 1. a , 2. c , 3. b , 4. e

Frame 5

Clevis bolts are used in applications subject to shearing stress only, such as shown in the illustration to the left below, where the force exerted on the bolt itself is crosswise on the shank. Clevis bolts are also used as mechanical pins in control systems.





Circle the letter that identifies the correct answer for the following question.

What bolt is used where shear strength is needed?

a. Plain head aircraft bolt.

b. Drilled head aircraft bolt.

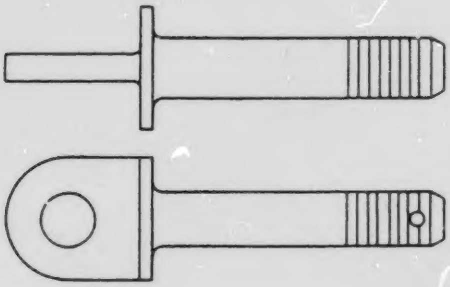
c. Clevis bolt.

d. Eyebolt.

ANSWERS TO FRAME 4: _T_ 1., _F_ 2.

Frame 6

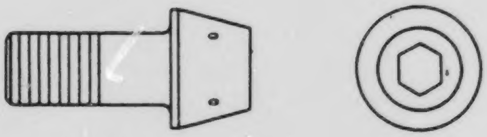
Eyebolts are used to carry external tension loads for the attachment of devices; such as, the fork of a turnbuckle, a clevis, or a cable shackle.



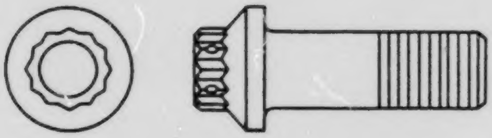
No Response Required

ANSWER TO FRAME 5: c

Internal wrenching bolts are high strength steel bolts used primarily in tension applications. Either the bolt hole must be countersunk to seat the larger corner radius of the shank at the head, or a special heat-treated washer must be used to fit the head and to provide adequate bearing area. A special plain washer, also heat-treated, is used under the nut which is also a special nut for use with these bolts.



The external wrenching bolt, which is a non-standard bolt, has a 12-point head. This bolt has greater fatigue resistance, tensile strength, and ductility than conventional bolts.



Indicate if the following statements are TRUE or FALSE by placing a T or an F in each space provided.

_____1. An external wrenching bolt is stronger than a conventional bolt.

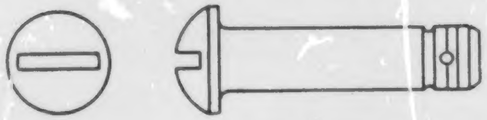
_____2. An internal wrenching bolt may be used with any type of nut.

ANSWER TO FRAME 6: No Response Required

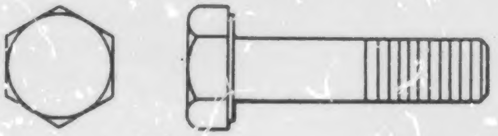
.278 Frame 8

Match the illustrations shown below to their correct names listed in the column on the right.

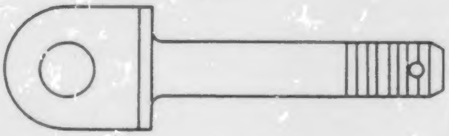
____1.



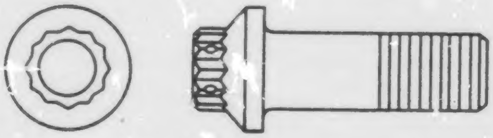
____2.



____3.



____4.



a. Standard aircraft bolt.

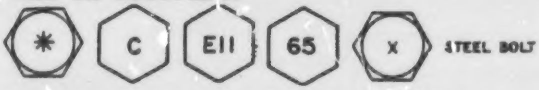
b. Eyebolt.

c. External wrenching bolt.

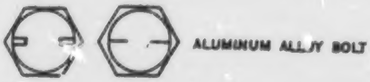
d. Clevis bolt.

ANSWER TO FRAME 7: __T__ 1., __F__ 2.

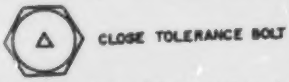
Bolts are marked with a code to identify their physical characteristics and materials. Steel alloy bolts are marked with an asterisk (*) with letters from A to Z, or numbers from 0 to 9, or any combination of letters, numbers, and an asterisk.


*
C
E11
65
X
STEEL BOLT

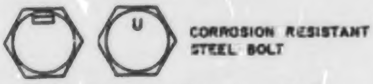
Aluminum alloy bolts are marked with raised or recessed dashes on opposite sides of the bolt head.


ALUMINUM ALLOY BOLT

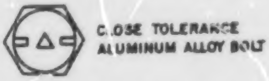
Steel and aluminum alloy close-tolerance bolts are identified by a raised or recessed triangle on top of the head.

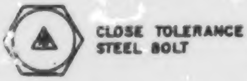

CLOSE TOLERANCE BOLT

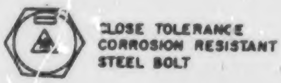
Corrosion resistant steel bolts are identified by a single raised or recessed dash on top of the head.


U
CORROSION RESISTANT
STEEL BOLT

Some bolts may have a combination of materials or other characteristics and are identified as shown below.


CLOSE TOLERANCE
ALUMINUM ALLOY BOLT


CLOSE TOLERANCE
STEEL BOLT


CLOSE TOLERANCE
CORROSION RESISTANT
STEEL BOLT

Match each bolt pictured to its word description.

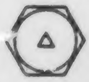
_____1. Close tolerance aluminum alloy bolt.

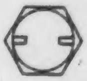
_____2. Steel bolt (alloy).

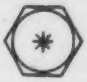
_____3. Corrosion resistant steel bolt.

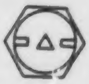
_____4. Aluminum alloy bolt.

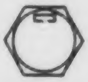
_____5. Close tolerance bolt.

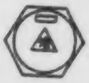
a. 

b. 

c. 

d. 

e. 

f. 

ANSWER TO FRAME 8: 1. __d__ 2. __a__ 3. __b__ 4. __c__

Frame 10

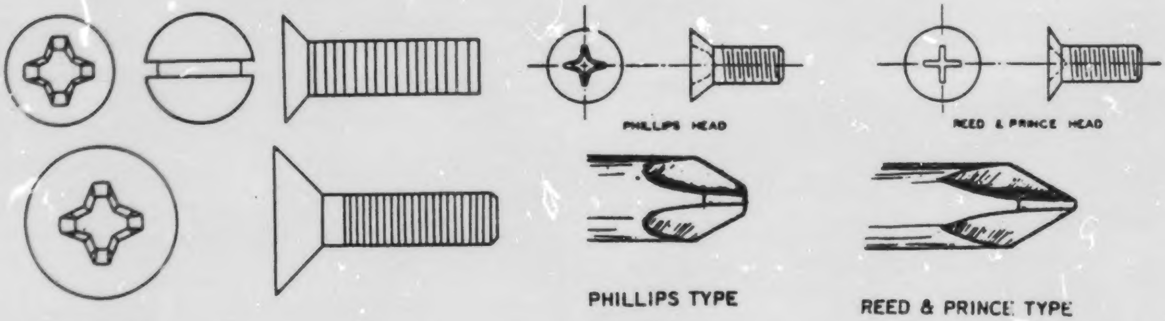
Screws are the most common type of threaded fasteners used on aircraft. They differ from bolts mainly by having a lower material strength, a looser thread fit, and shanks threaded along their entire length. The different types of screws have various types of slots or recesses, and each type requires a particular type of screwdriver. For proper performance and to prevent mutilation of the screw head and the screwdriver always use the proper type of screwdriver.

Of the four main groups of screws, the two which we are primarily concerned with are machine screws and self-tapping screws.

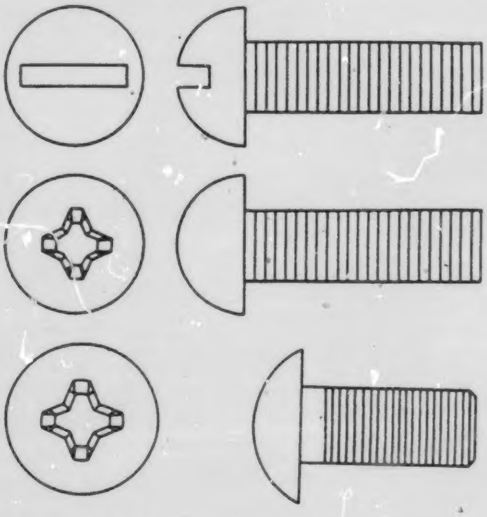
No Response Required

ANSWERS TO FRAME 9: 1. d 2. c 3. e 4. b 5. a

Flathead machine screws are used in countersunk holes where a flush surface is desired. These screws have various types of recesses, i.e., slots and crosspoints, such as Phillips and Reed and Prince.



General purpose roundhead machine screws, like flathead machine screws, are manufactured from different materials; such as carbon steel, corrosion-resistant steel, aluminum alloy, and brass. These screws have coarse or fine threads and slotted or recessed heads. Brass roundhead machine screws with slotted heads are intended for electrical use only.



Answer the following questions either by supplying the information required or by indicating T for true or F for false.

1. A flathead machine screw is used in a __________ hole where a flush surface is required.

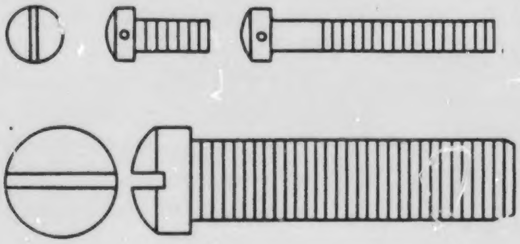
_____2. A brass roundhead machine screw is designed for general purpose use.

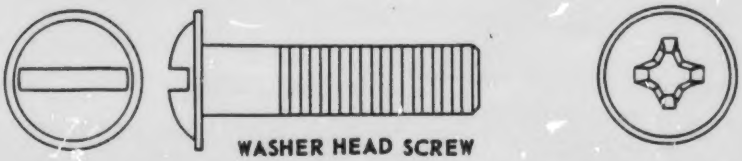
ANSWERS TO FRAME 10: No Response Required

.282

Frame 12

Fillister head machine screws, shown in the illustration, are used as general purpose screws and also as cap screws in light mechanics. The heads are usually drilled to accept safety wire. Fillister head screws are available in steel and brass with coarse or fine threads.





The washer head screw, while not a machine screw, is often used in the same manner as structural bolts and rivets in the primary structure of aircraft. These screws have a high tensile strength and differ from structural bolts only in the type of head.

Circle the letter of the correct completion to the statement below.

The type of screw which has a drilled head to accept safety-wire is the

a. washer head screw.

b. flathead machine screw.

c. fillister head machine screw.

d. roundhead machine screw.

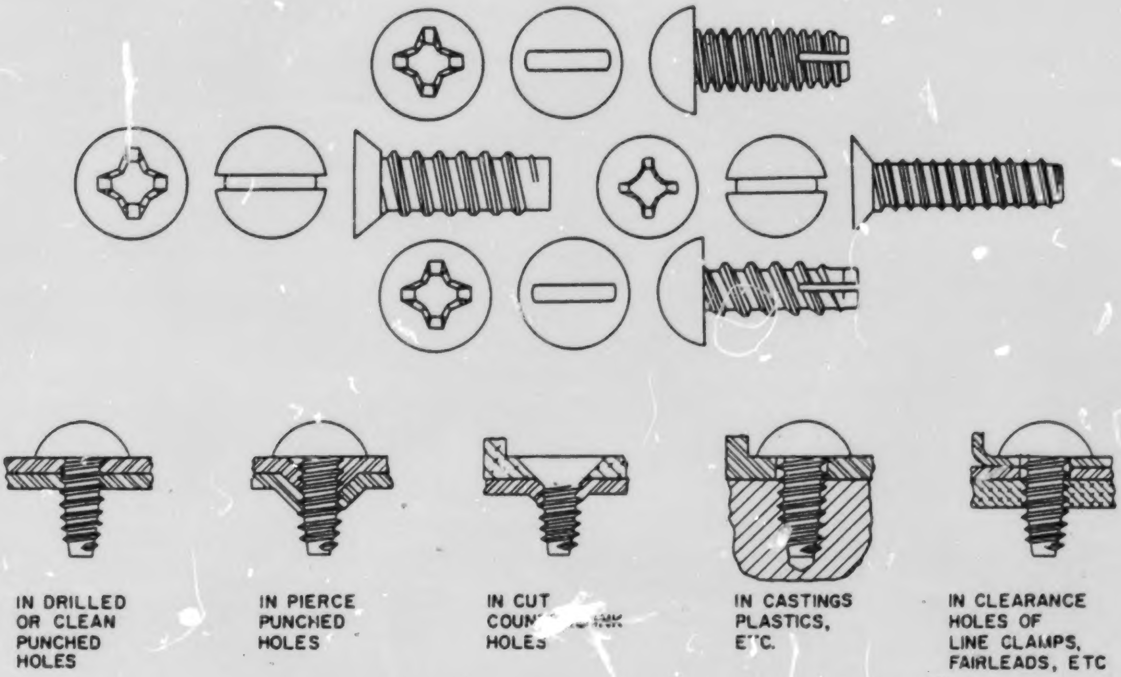
ANSWERS TO FRAME 11: 1. countersunk, __F__ 2.

394

Frame 13

Self-tapping screws tap their own mating threads when driven into untapped or punched holes slightly smaller than the outside diameter of the screw itself.

Self-tapping sheet metal screws are used for such purposes as temporarily attaching sheet metal for riveting and for permanent assembly of nonstructural assemblies located in blind areas. Sheet metal screws are hardened for use on steel or aluminum sheets, but may be used on plastic also.


IN DRILLED OR CLEAN PUNCHED HOLES
IN PIERCE PUNCHED HOLES
IN CUT COUNTERSUNK HOLES
IN CASTINGS PLASTICS, ETC.
IN CLEARANCE HOLES OF LINE CLAMPS, FAIRLEADS, ETC

Using Sheet Metal Screws

Indicate if each of the following statements is TRUE or FALSE by placing a T or an F in the space provided.

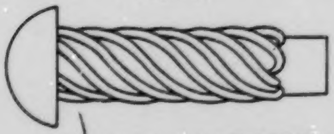
_____1. In a permanent installation, sheet metal screws must be used in tapped holes or with self-locking nuts.

_____2. Self-tapping screws are usually driven into the hole by using a hammer.

ANSWER TO FRAME 12: c

Frame 14

Drive screws are self-tapping screws used to attach nameplates to castings and to seal drain holes in tubular structures. They differ from other self-tapping screws in that the heads are not formed to fit screwdrivers, and they are not intended to be removed after installation. Drive screws are installed by driving the screw into a drilled hole with a hammer.



ROUNDHEAD DRIVE SCREW

Circle the letter of the correct completion to the following statement.

The correct letter for installing a drive screw is a

a. Phillips screwdriver.

b. Reed and Prince screwdriver.

c. common screwdriver.

d. hammer.

ANSWER TO FRAME 13: F 1., F 2.

Frame 15

Using the illustrations below, match the screws to their correct names.

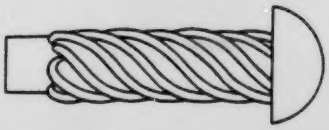
_____1. Machine screw, flathead.

_____2. Machine screw, fillister head.

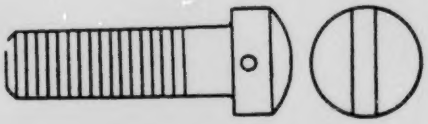
_____3. Self-tapping sheet metal screw.

_____4. Drive screw.

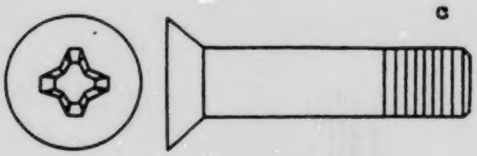
a



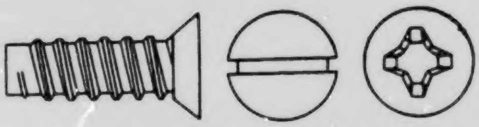
b



c



d



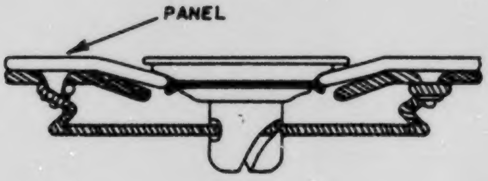
ANSWER TO FRAME 14: d

Frame 16

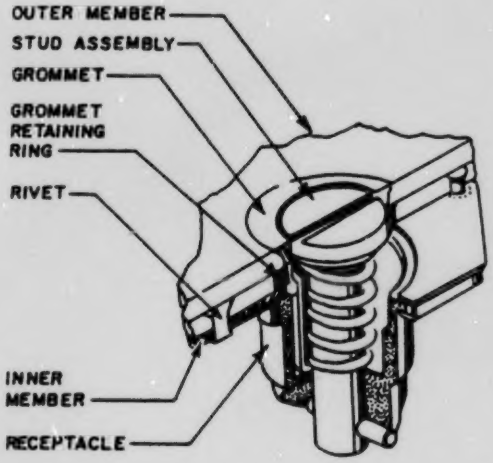
Fasteners are used on aircraft access panels, plates, doors, cowling (engine covering), etc. where quick or frequent access is necessary in performing maintenance, servicing, or inspecting components. The two types of fasteners we will cover heare are turnlock (Dzus and Airlock) and camlock fasteners. One-quarter of a turn locks or unlocks these fasteners.

Turnlock fasteners (see illustration "A") are not designed to carry primary structural stress so they are used on cowling (engine covering) and access doors.

Camlock fasteners (see illustration "B") are of relatively high strength and they are used in some areas on structural access panels and doors.



TURNLOCK FASTENER
"A"



CAMLOC FASTENER
"B"

Circle the letter of each correct statement.

a. Fasteners are used where frequent and quick accesses are required.

b. Turnlock fasteners can carry high structural stresses.

ANSWERS TO FRAME 15: 1. c 2. b 3. d 4. a

Frame 17

Circle the letter that identifies the correct answer to each of the following questions.

1. What type of screw is used to attach panels to aircraft where there is a threaded hole in the aircraft?

   a. Machine screw.

   b. Drive screw.

   c. Sheet metal screw.

   d. Crosspoint screw.

2. The type of machine screw which has a drilled head for securing safety wire is the

   a. flathead machine screw.

   b. washer head structural screw.

   c. round head machine screw.

   d. fillister head machine screw.

3. For quick access, panels, cowling, and plates are secured to the aircraft with

   a. flathead machine screws.

   b. sheet metal screws.

   c. fasteners.

   d. fillister head machine screws.

4. A screw that has high tensile strength and is used in the primary structure of aircraft is the

   a. sheet metal screw.

   b. drive screw.

   c. crosspoint screw.

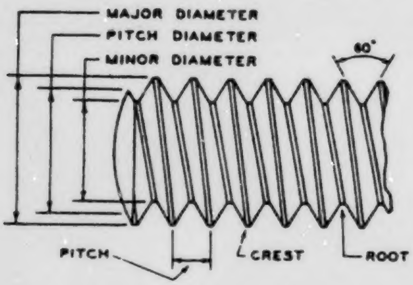
   d. washer head screw.

ANSWER TO FRAME 16: a

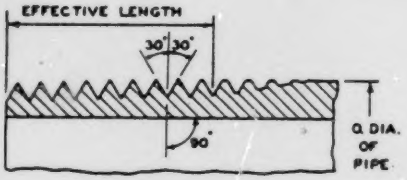
288. Frame 18

The more common forms of screw threads are known as national coarse series, national fine series, national extra fine series, and American national taper pipe threads. Screw threads are also classified according to fit; i.e., Class 1 (loose fit), Class 2 (free fit), Class 3 (medium fit) which is generally employed in aircraft construction, and Class 4 (close fit). Threads are generally designated by symbols according to their type and fit, such as NC-2 (National coarse free fit). Right and left hand threads are designated by RH and LH.

Screw Thread Forms.


MAJOR DIAMETER
PITCH DIAMETER
MINOR DIAMETER
60°
PITCH
CREST
ROOT

① NATIONAL SCREW THREAD


EFFECTIVE LENGTH
30° 30°
90°
O. DIA. OF PIPE

② NATIONAL PIPE THREAD

Circle the letter of each correct statement below.

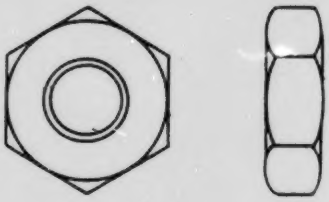
a. A screw with national corase threads and classified as "medium fit" is used in aircraft construction.

b. Class 4 threads fit very loosely.

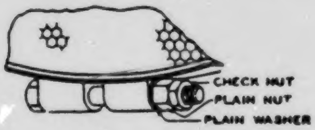
c. No series of national threads are available in left hand screw threads.

ANSWERS TO FRAME 17: 1. a 2. d 3. c 4. d

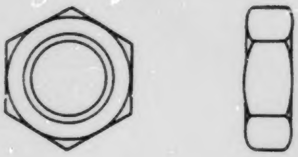
Plain nuts are nonself-locking. When nonself-locking nuts are used they are locked with an auxiliary locking device such as a checknut or lockwasher. Checknuts are shown in the illustration below.

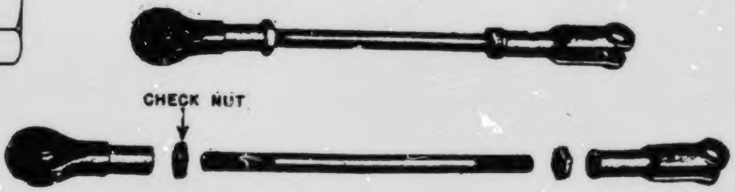


Safetying by Use of Nuts.



A checknut (Pal nut, Jam nut) is a plain nonself-locking nut used for locking another nonself-locking plain nut. They are also used as locking devices for setscrews and threaded rod ends. Two applications of checknuts are shown in the illustrations above and below using plain nonself-locking nuts.





Check each true statement below.

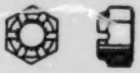
_____1. An alternate method of locking (safetying) a nonself-locking plain nut is through the use of safety wire.

_____2. A checknut may be smaller than the plain nut that it is going to lock.

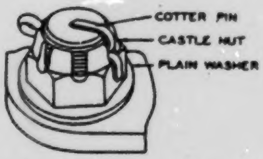
ANSWER TO FRAME 18: a

290 Frame 20

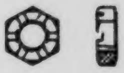
Castle nuts are used with drilled shanks, hexhead bolts, clevis bolts, and drilled studs. These nuts are designed to be secured with cotter pins or safety wire. The multiple slot arrangement permits proper adjustment of tension with the correct alignment of slots and holes. The illustration below shows the proper installation of a cotter pin to secure a castle nut. The shear nuts, shown below, are also designed for use with drilled clevis bolts and threaded taper pins which are normally subjected to shearing stress instead of tension, as in the case of castle nuts previously mentioned. A shear nut has approximately three complete threads below the castellations and can be identified easily because of its thinness. Shear nuts are also available in the self-locking style.



CASTLE NUT

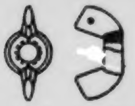


Safetying by Use of Cotter Pins.



SHEAR NUT

The wingnut shown below is used where the desired tightness is obtained by the use of the fingers and where the assembly is frequently removed. When safetying of this nut is required, a hole is drilled through one of the "wings" (see illustration) and secured with safety wire.



WING NUT

Check each true statement below.

_____1. The correct use for a castle nut is with a drilled head bolt.

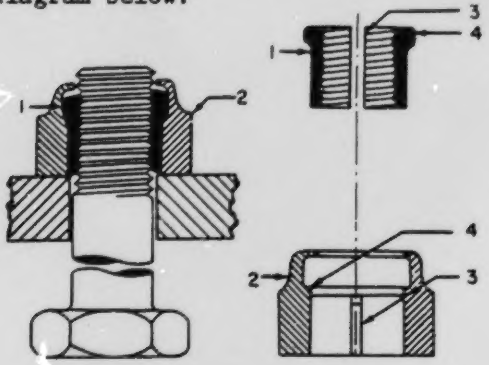
_____2. A shear nut is most generally used with a clevis bolt.

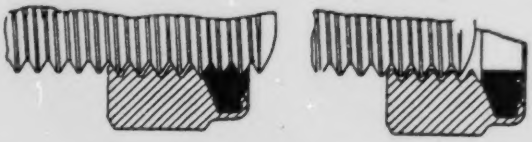
_____3. Wing nuts are used where the desired tightness is obtained by the use of the fingers.

ANSWER TO FRAME 19: _____1., __✓__2.

Frame 21

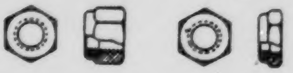
Nonmetallic type self-locking nuts have a nylon insert of smaller inside diameter than the major diameter of the bolt. The nylon exerts a compressive locking force against the bolt, as illustrated in the diagram below.





1 THREADED NUT CORE
2 NUT CASE
3 KEYWAY
4 LOCKING SHOULDER

As may well be expected, nonmetallic insert self-locking nuts cannot be subjected to temperatures in excess of 250 degrees Fahrenheit. As shown in the diagram below, self-locking nuts are available in thick or thin styles.



SELF LOCKING NUTS

Metal self-locking nuts, which are similar to nonmetallic self-locking nuts except for the type of insert, are used where temperatures are extremely high (3060° F, exhaust section of a jet engine) and where nonmetallic self-locking nuts cannot be used. The all metal self-locking nut has threads out of phase or pinched in at the top to bind the bolt and maintain tightness.

If a self-locking nut can be run down with the fingers, after the locking feature engages the bolt or stud, it indicates that the locking friction does not exist and the nut should be replaced.

Circle the letter of the correct answer to the following statement.

The type of nut which must not be used in applications where the temperature is above 250° F is the

a. castle nut.

b. all metal self-locking nut.

c. nonmetallic self-locking nut.

d. plain nut.

ANSWERS TO FRAME 20: ____ 1., ✓ 2., ✓ 3.

Frame 22

Match the descriptions on the right with the names on the left.

_____1. Nonmetallic self-locking nut.

_____2. Castle nut.

_____3. All metal self-nut.

_____4. Plain nut.

a. Has slots at the top to be used with drilled bolts with a cotter pin to maintain its position.

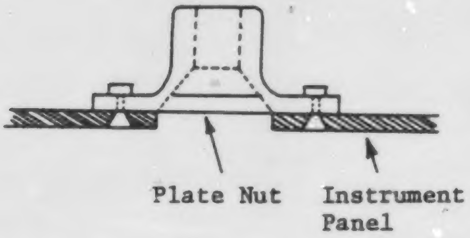
b. Has threads out of phase or pinched in at the top to bind on the bolt and maintain tightness.

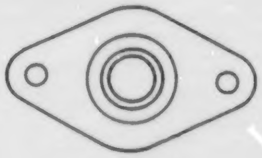
c. Requires an auxiliary locking device, such as a checknut or lockwasher.

d. Has a nylon insert at the top to bind on the bolt and maintain tightness.

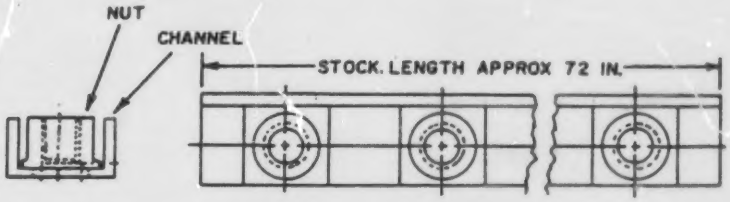
ANSWERS TO FRAME 21: c

Plate nuts are used for blind mounting in inaccessible locations and for easier maintenance. They can be either self-locking or plain. They are available in a wide range of sizes and shapes. One lug, two lugs, and right-angle shapes are available to accommodate the requirements of the individual nut location. Floating-type nuts provide a controlled amount of nut movement to compensate for subassembly misalignment.





Gang channel nuts are used in applications requiring anchored nuts equally spaced around openings such as access and inspection doors and removable leading edges. Straight or curved channel strips offer a wide range of nut spacings and provide a multiple nut unit that has all advantages of float-type nuts. They are usually self-locking.



Check each true statement.

_____1. Plate nuts are used for mountings that are easy to reach.

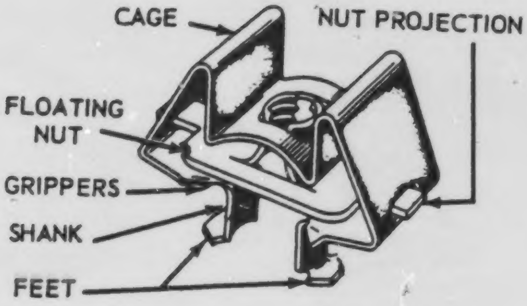
_____2. A float-type nut has some movement to compensate for misalignment of subassemblies.

_____3. Gang channel nuts are anchored and equally spaced.

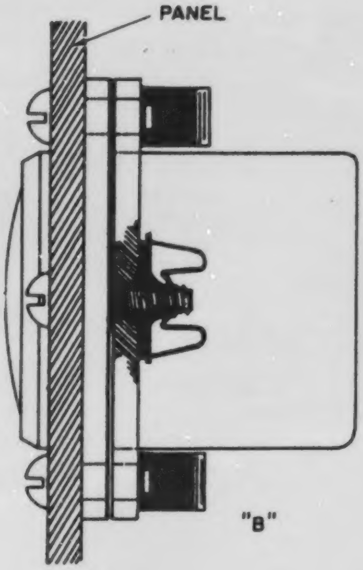
ANSWERS TO FRAME 22: 1. d 2. a 3. b 4. c

Frame 24

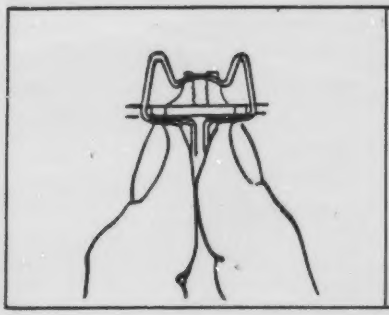
Tinnerman mounting nuts are used primarily for front mounting of aircraft components. However, the nuts may be inserted in the instrument for rear mounting (see illustration "B"). The nut is made of nonmagnetic material and is used with a standard component mounting screw size 6-32 only. The names of the various parts of the nut are shown in illustration "A". There are several shank lengths to fit the different panels and bezel thicknesses. Illustrations "C" through "F" show the installation of the nut in the instrument panel.


CAGE
NUT PROJECTION
FLOATING NUT
GRIPPERS
SHANK
FEET

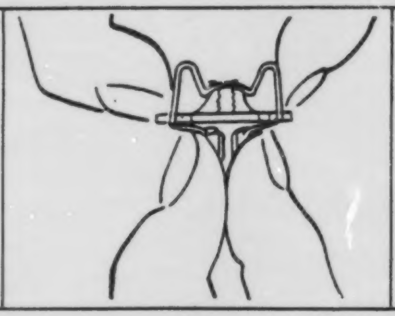
"A"



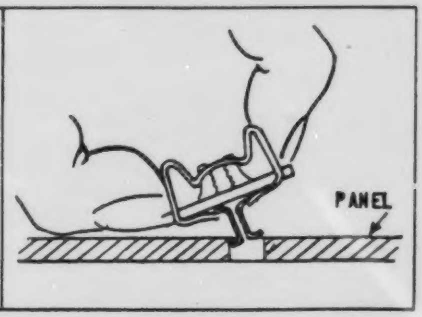
"B"



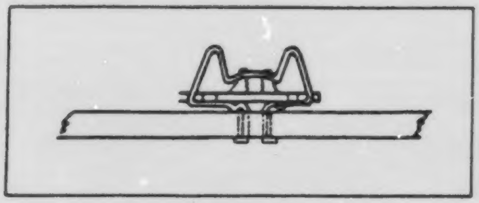
"C"



"D"



"E"



"F"

ANSWERS TO FRAME 23: ____ 1., __✓__ 2., __✓__ 3.

Circle the letter of each correct statement.

a. Tinnerman mounting nuts come in several sizes.

b. Tinnerman mounting nuts can be used on front-bezel mounted instruments only.

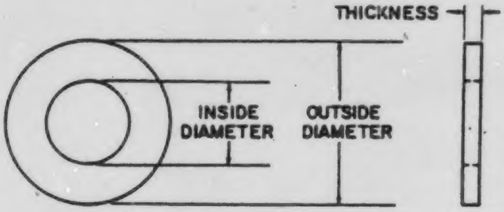
c. Tinnerman mounting nuts are available in several different shank lengths.

d. Tinnerman mounting nuts that are attached to the component would require the instrument to be rear-bezel mounted.

Frame 25

The types of washers used in aircraft structures are plain washers, lockwashers, and special washers.

Plain washers are used under nuts to provide a smooth bearing surface to act as shims in obtaining the correct relationship between the threads of the bolt and nut, and in adjusting the position of castellated nuts with respect to drilled cotter pin holes in bolts. They are also used under lockwashers to prevent damage to surfaces of soft material.



Circle the letters of the correct answers to the following statement.

Plain washers are used under nuts to

a. prevent a galvanic action from dissimilar metals.

b. provide a smooth bearing surface.

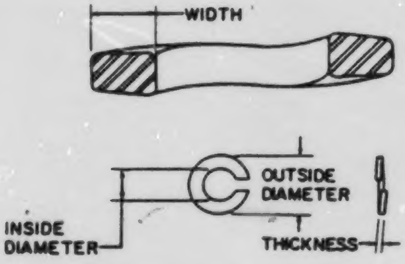
c. prevent loosening of threaded fasteners.

d. act as shims between the threads of bolts and nuts.

ANSWERS TO FRAME 24: c, d

Frame 26

Lockwashers are used with plain nuts when self-locking or castellated type nuts are not applicable. The spring action of the washer prevents the nut from working loose. Lockwashers are not to be used on primary structures, secondary structures, superstructures, or accessories where failure might result in damage or danger to aircraft or personnel. The following diagram shows a typical example of lockwashers.



LOCKWASHER

Choose the letter of the correct answer for the following statement.

Lockwashers are used with plain nuts

a. when self-locking or castellated type nuts are not applicable.

b. on primary and secondary structures.

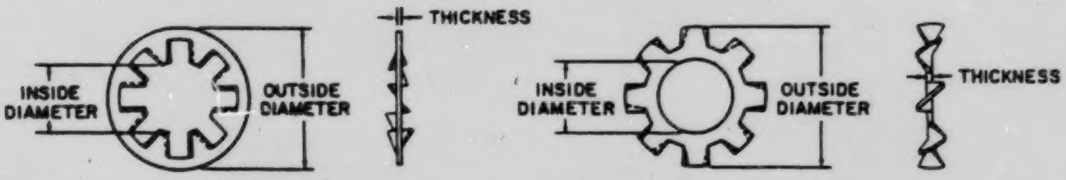
c. on soft metals without plain washers.

d. on exposed surfaces subject to airflow.

ANSWERS TO FRAME 25: b, d

Frame 27

Other types of lockwashers may have internal teeth or external teeth, as shown here. The teeth are twisted slightly so as to provide a locking effect when tightened down.

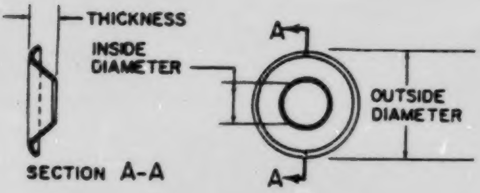

THICKNESS
INSIDE DIAMETER
OUTSIDE DIAMETER
INSIDE DIAMETER
OUTSIDE DIAMETER
THICKNESS

INTERNAL TEETH

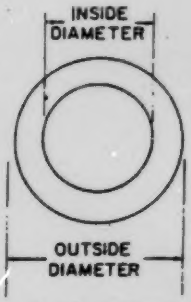
EXTERNAL TEETH

LOCKWASHER

There are many types and varieties of special washers. Some special washers are illustrated in the diagrams. They are finishing washers, phenolic fiber washers, tab type washers, etc.

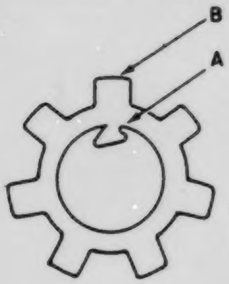

THICKNESS
INSIDE DIAMETER
A
OUTSIDE DIAMETER
SECTION A-A
A

COUNTERSUNK TYPE, FINISHING WASHER


INSIDE DIAMETER
OUTSIDE DIAMETER

FLAT, PHENOLIC FIBER WASHER

The tab washer is used where vibrations might tend to loosen a nut from a bolt. The bolt would have a slot cut into it for tab A, shown in the figure, to slide into. After the nut is tightened, one or more of the tabs (B) are bent back against the sides of the nut which prevents it from loosening.

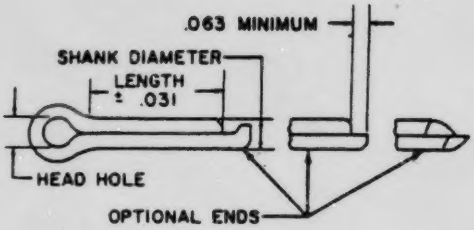


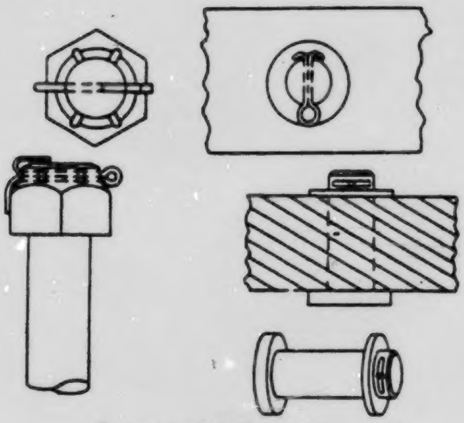
TAB TYPE WASHER

No Response Required

ANSWER TO FRAME 26: a

Cotter pins are used to secure bolts, screws, nuts, pins, and in other applications where such securing is required. A cotter pin is a "split" metal pin which is inserted in a hole and then spread apart, one half each way. Their use is favorable because they can be removed and installed quickly. They are available in lengths from 5/16 inch to 4 inches, with diameters from .031 inch to .250 inch. The diameter selected for an application should be the largest size that will fit the cotter pin hole and/or the slots in the nut. The following diagrams show some of the different types of cotter pins and methods of securing with cotter pins.

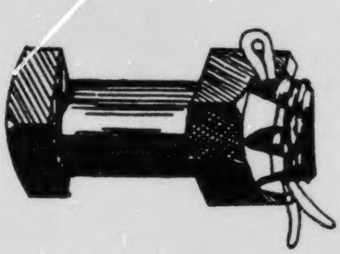




Securing With Cotter Pins

Circle the letter in front of the correct answer to the following question.

What is the purpose of the cotter pin installed as shown in the diagram below?



a. To keep the nut from wobbling and thereby ruining the nut threads.

b. To hold the bolt in place.

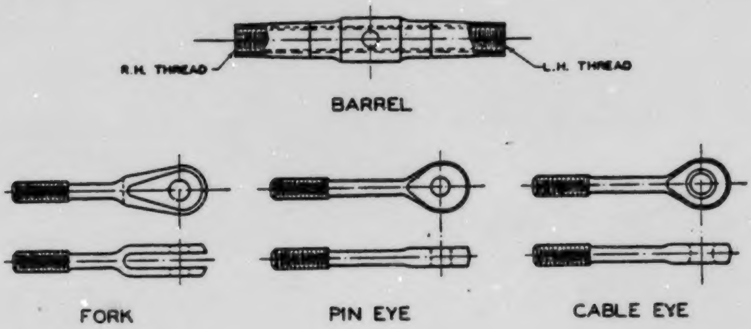
c. To keep the nut from damaging the bolt threads.

d. To keep the nut from loosening.

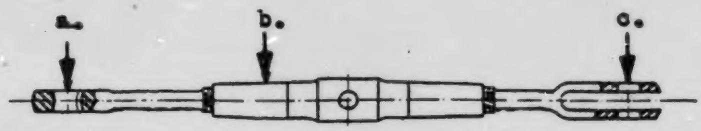
ANSWER TO FRAME 27: No Response Required

Frame 29

The turnbuckle is a device used to adjust the tension on aircraft cables. It consists of a brass barrel with right hand threads on one end and left hand threads on the other, and a bolt type device screwed into each end. The three types of turnbuckle ends are known as fork, pin eye, and cable eye. These parts are shown below. Take a look at them. With the left and right hand threads in the barrel, turning the barrel one way will tighten both ends and the other way will loosen both ends.



Match the letters in the illustration to their correct names on the left.



_____1. Barrel.

_____2. Fork end.

_____3. Cable eye end.

Circle the letter that identifies the correct answer.

4. What is the designed use of a turnbuckle?

   a. Holds two pieces of metal securely together.

   b. Used to safety a cable connection.

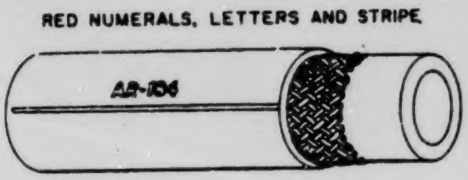
   c. To determine if a bolt has left or right hand threads.

   d. Used to adjust cable tension.

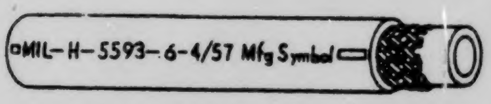
Answer to Frame 28: 1. d.

Flexible hose and flexible hose assemblies are used when there is an excessive amount of vibration. They are also used when the unit they connect to moves during flight.

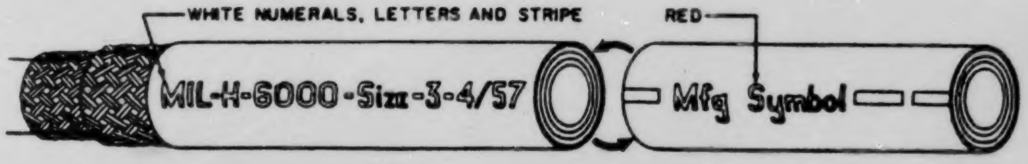
Flexible hose is marked with a series of dots and dashes and letters (as shown below). These markings are used for identification. The markings are color coded to show different types of hose. The markings on the hose show several things: manufacturer, the military specification, the size, and the date of manufacture. The size of the hose is the inside diameter measured in sixteenths of an inch. The manufacture date is shown by the quarter of the year and the year the hose was made.


RED NUMERALS, LETTERS AND STRIPE
AN-104

Self-Sealing, Aromatic-Resistant Hose.


MIL-H-5593-6-4/57 Mfg Symbol
YELLOW NUMERALS, LETTERS AND STRIPE

Nonself-Sealing, Aromatic-Resistant Hose, Military Specification MIL-H-5593 (NOT HEAT RESISTANT)


WHITE NUMERALS, LETTERS AND STRIPE
RED
MIL-H-6000-Size-3-4/57
Mfg Symbol

(VIEWS SHOWING OPPOSITE SIDES OF HOSE)

Nonself-Sealing, Aromatic- and Heat-Resistant Hose, Military Specification MIL-H-6000

NO RESPONSE REQUIRED

Answers to Frame 29: __b__ 1. __c__ 2. __a__ 3. 4. d.

302

Frame 31

Like the flexible hose, tubing is measured in sixteenths of an inch. However, tubing is measured on the outside diameter. If a tubing is 1/2 inch in diameter it would be referred to as a number 8 tubing. This is because 1/2 inch is 8 sixteenths of an inch. Tubing size varies from 1/8 inch to 2 1/4 inches. This is shown as a number 2 to a number 36.

Is the following statement TRUE or FALSE?

_____1. A number 6 fitting would be used with 3/8 inch OD tubing.

Answer to Frame 30: None required.

The tubing most commonly used in aircraft systems is made of aluminum alloy. Aluminum tubing is light and can be formed and bent easily; therefore, care must be taken in handling it so that it will not be damaged. Corrosion resistant steel tubing, which is stronger but not as easily formed, is often used on hydraulic systems operating at 3000 psi or highter.

Tubing size is determined by measuring the outside diameter (OD) in sixteenths of an inch. The top half of the fraction is the tubing size number. Example: A 1 inch OD tube is called number 16 tubing. 1" - 16/16ths - #16 tubing. 7/8 inch tubing is number 14 tubing 7/8" = 14/16ths = #14 tubing.

Match each size tubing on the left with the outside diameter measurements on the right.

____1.	Number 4 tubing.	a.	5/8" OD.
____2.	Number 6 tubing.	b.	1/4" OD.
____3.	Number 8 tubing.	c.	1/2" OD.
____4.	Number 10 tubing.	d.	3/4" OD.
____5.	Number 12 tubing.	e.	3/8" OD.

Frame 33

Match the outside diameter measurements on the left with the appropriate tubing sizes on the right. Always record your answers.

____1.	1 1/2" OD tubing.	a.	Number 1 1/2 tubing.
____2.	1 1/4" OD tubing.	b.	Number 16 tubing.
		c.	Number 1 1/4 tubing.
		d.	Number 20 tubing.
		e.	Number 24 tubing.

Answer to Frame 31: TRUE

Frame 34

The size of a fitting is determined by the outside diameter of the tubing to which it connects.

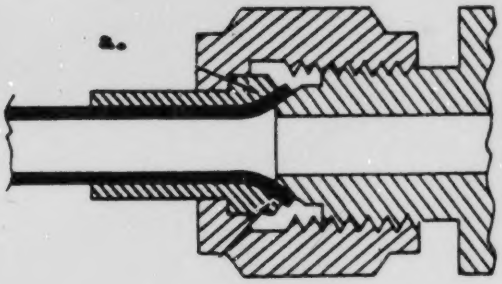
The Air Force uses two types of fittings with tubing; AN FLARE fittings, and MS FLARELESS fittings. AN fittings have a sleeve with a beveled edge to fit the flare of the tubing and to form a seal when the tubing nut is drawn tight. Tubing used with MS fittings is not flared. When the tubing nut is tightened on an MS fitting the sleeve is wedged between the tubing and the fitting to form a seal. The torque on MS fittings is critical. Too much torque will cause them to leak.

Match the two illustrations with the correct nomenclature.

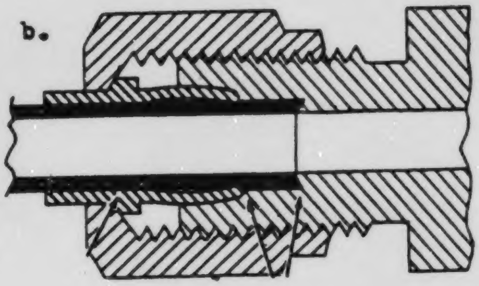
_____1. AN fitting.

_____2. MS fitting.

a.



b.



Select the correct answer for each of the following items.

3. What type fitting is used with tubing that is not flared?

a. AN fitting.
b. MS fitting.
c. Both.
d. Neither.

4. What type fitting is used with flared tubing?

a. AN fitting.
b. MS fitting.
c. Both.
d. Neither.

Answers to Frame 32: __b__1. __e__2. __c__3. __a__4. __d__5.

Answers to Frame 33: __e__1. __d__2.

Match the illustrations with the correct uses.

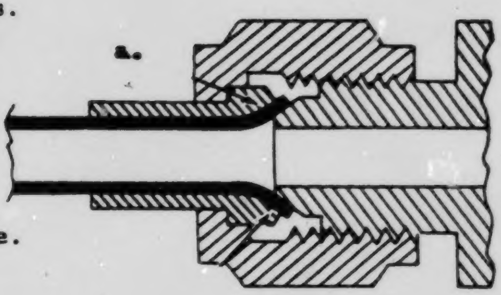
_____5. Used when tubing is not flared.

_____6. Connects different sized tubing.

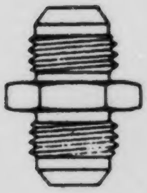
_____7. Used with flared tubing.

_____8. Connects two tubes of the same size.

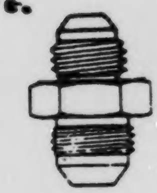
a.



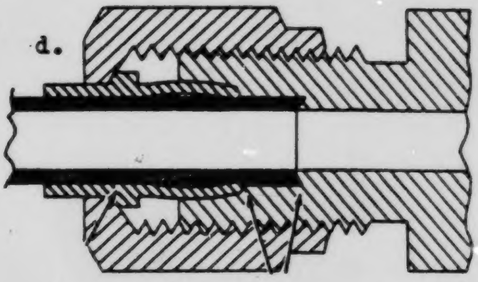
b.



c.



d.



Frame 35

Fitting types and material are identified by color. Aluminum AN fittings are blue. Steel AN fittings are black. Aluminum MS fittings are gray or light yellow. Steel MS fittings are dark yellow. These fittings are not interchangeable. Steel fittings are used for high pressure where aluminum fittings will not hold. AN fittings must have flared tubing while MS fittings will not fit flared tubing.

Match the identifying color with each type fitting.

_____1. MS aluminum fitting. a. Dark yellow.

_____2. AN aluminum fitting. b. Blue.

_____3. MS steel fitting. c. Gray or light yellow.

_____4. AN steel fitting. d. Silver.

e. Black.

Frame 36

Match the information below.

_____1. Connects different sized tubing.

_____2. Used where tubing is flared.

_____3. Connects two pieces of the same size tubing.

_____4. Used with flareless tubing.

a. Reducer.

b. Union.

c. MS fitting.

d. AN fitting.

Frame 37

Match the illustrations to their names.

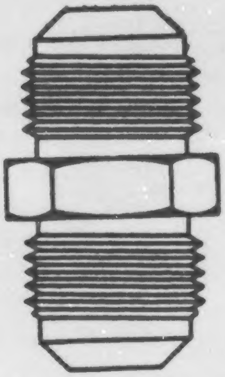
_____1. AN fitting.

_____2. MS fitting.

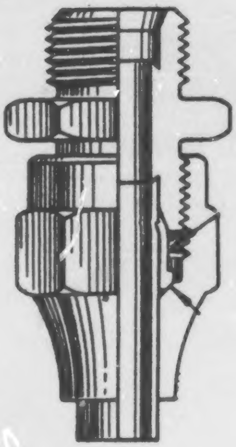
_____3. Union.

_____4. Reducer.

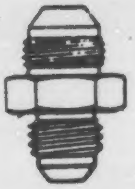
a.



b.



c.



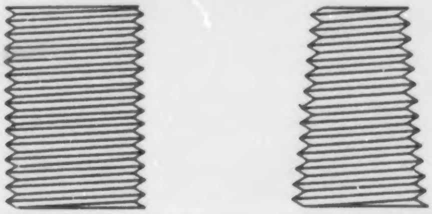
Answers to Frame 34: a 1. b 2. 3. b. 4. a. d 5.

c 6. a 7. b 8.

Answers to Frame 35: c 1. b 2. a 3. e 4.

AN standard fittings have superseded all other types of fittings. They should be used in preference to all other flared fittings. Fitting sizes should correspond to the size of tubing they are used with. Tubing fittings have either tapered pipe threads or straight threads. Pipe thread fittings are made in a cone shape. Straight threads are the same in diameter the entire length of the threads.

The hole the pipe thread fitting goes into is tapered like the fitting. As the pipe thread fitting is screwed in, its threads seal against the threads of the hole.



STRAIGHT THREAD PIPE THREAD

NO RESPONSE REQUIRED

Answers to Frame 36: a 1. d 2. b 3. c 4.

Answers to Frame 37: a 1. b 2. a 3. c 4.

Frame 39

Fitting types and materials are identified by color. AN aluminum fittings are blue. AN steel fittings are black. Aluminum bronze fittings are cadmium plated and are not otherwise colored. These fittings are not interchangeable, because if two dissimilar (unlike) metals are brought together they will corrode. Corrosion can cause a potential fire hazard in the presence of oxygen, or a weakness in the metal.

Match the identifying color with each type of fitting.

_____1. AN aluminum fitting.   a. Dark yellow.

_____2. AN steel fitting.   b. Blue.

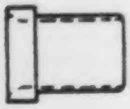
c. Gray or light yellow.

d. Silver.

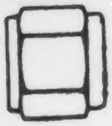
e. Black.

Answer to Frame 38: None required.

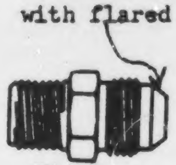
A flare and a sleeve, with a nut, are used when connecting straight threads to tubing. The sleeve is used to seal the tubing to the nut and to the fitting. The nut, of course, is used to connect the tubing to the fitting. The nipple is used to connect a piece of tubing to a device having pipe threads.



Sleeve:



Nut: Coupling.


Bevelled surface mate, with flared tubing
Pipe thread
Straight thread

Nipple

The flared tubing fittings most commonly used in the tubing systems of aircraft is the coupling nut and sleeve.

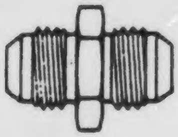
NO RESPONSE REQUIRED

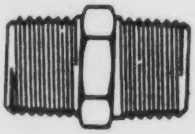
Answers to Frame 39: b 1. e 2.

Frame 41

Match the fittings to the descriptions listed below.

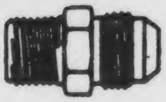
a.

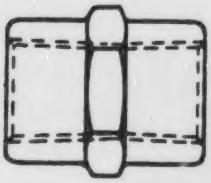




b.

c.





d.

_____1. Nipple, flared tubing to pipe.

_____2. Nipple, pipe thread on both ends.

_____3. Union, flared tube.

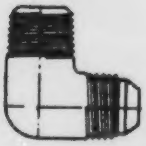
_____4. Coupling, internal pipe thread.

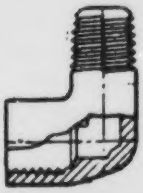
Answer to Frame 40: None required.

In this and the following frames you will be shown various AN fittings. You may well encounter these fittings at a later time in the performance of your job. Study the illustrations carefully. Then you will demonstrate your ability to identify these fittings. Let's see how well you do with the following.

Match the fittings to the descriptions listed below.

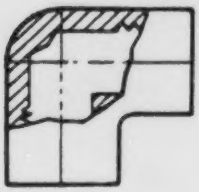
a.

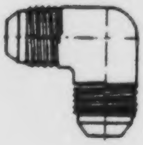




c.

b.





d.

_____1. Elbow, 90° flared tube.

_____2. Elbow, 90° internal and external pipe threads.

_____3. Elbow, 90° internal pipe threads.

_____4. Elbow, 90° flared tube to pipe.

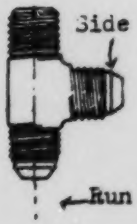
Answers to Frame 41: c 1. b 2. a 3. d 4.

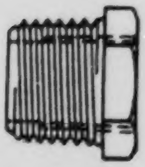
312

Frame 43

Match the illustrations below with their correct descriptions.

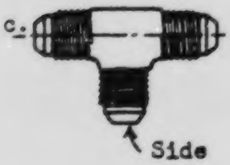
a.

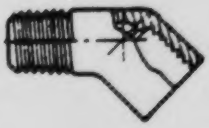




b.

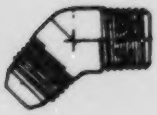
c.

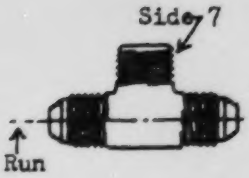




d.

e.





f.

_____1. Bushing, reducer.

_____2. Tee, flared tube.

_____3. Elbow 45° internal and external pipe threads.

_____4. Tee, flared tube, pipe thread on side.

_____5. Elbow 45° flared tube to pipe.

_____6. Tee, flared tube, pipe thread on the run.

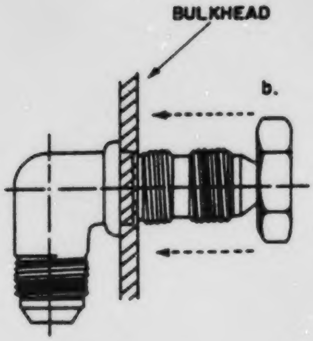
Answers to Frame 42: d 1. c 2. b 3. a 4.

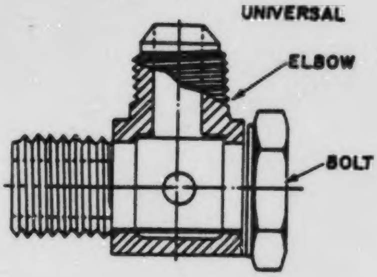
Frame 44

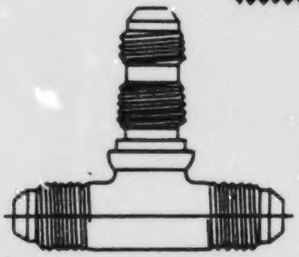
Bulkhead and universal fitting combinations can be mounted solidly to a bulkhead or component with one outlet adjusted to any angle. "Bulkhead" means that the fitting is long enough to go through a bulkhead. "Universal" means that the fitting can be set at any angle, using a universal fitting bolt.

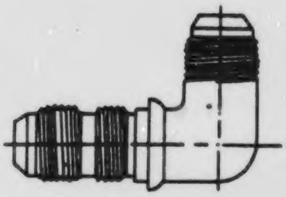
When installing a bulkhead fitting, a jam nut is used to hold the fitting securely in the bulkhead. This is shown in the following illustration. Fittings with evidence of visible damage, (stripped threads, deep gouges and nicks, wrench jaw marks, etc.) will be replaced.

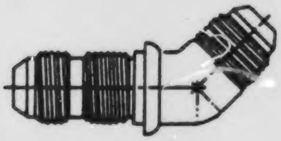
Match the fittings to the correct nomenclature listed below.

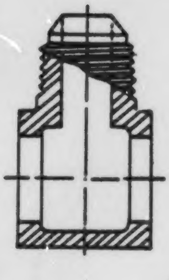


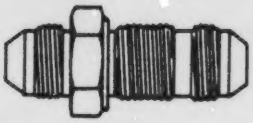


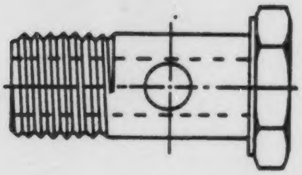

a.


d.


b.

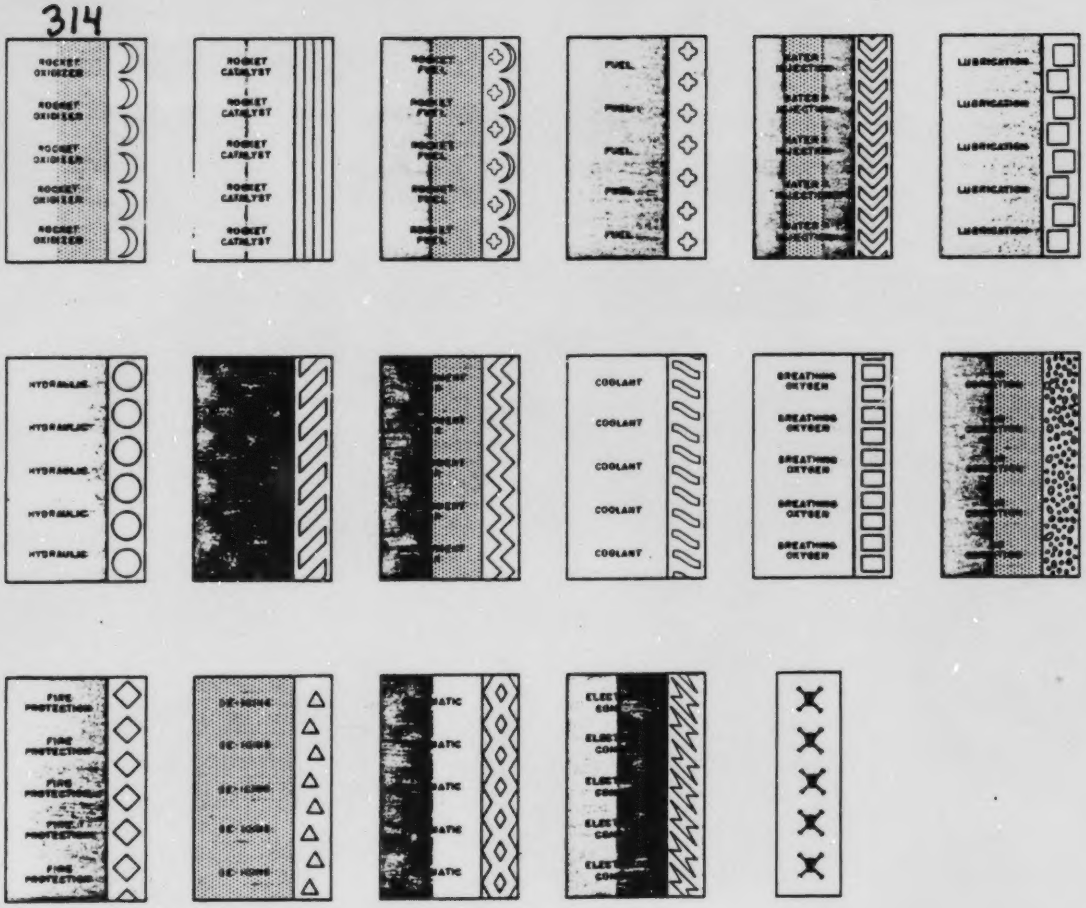

e.


c.


f.

____1. Bolt, universal fitting.
____2. Tee, flared tube, bulkhead.
____3. Elbow 90°, flared tube, bulkhead.
____4. Union, flared tube, extra length, for mounting in a bulkhead.
____5. Elbow, 90° universal.
____6. Elbow, 45°.

Answers to Frame 43: b 1. c 2. d 3. f 4. e 5. a 6.


ROCKET OXIDIZER
ROCKET CATALYST
ROCKET FUEL
FUEL
WATER INJECTION
LUBRICATION
HYDRAULIC
COOLANT
BREATHING OXYGEN
FIRE PROTECTION
DE-ICING
ELEC CON

Code bands of varicolored tape are attached to the tubing throughout the aircraft. These bands are placed near the joints and quickly identify the content and danger when working on or around these tubing.

A chart showing some of the color coding for tubing systems is shown above. This chart can be found in the appropriate technical orders.

Match the color code to the systems listed below.

_____1. Fire protection. a. Gray.
_____2. Lubrication. b. Blue-yellow.
_____3. Breathing oxygen c. Brown-gray.
_____4. Fuel d. Green.
_____5. Air condition. e. Yellow.
_____6. Pneumatic. f. Red.
_____7. Hydraulic. g. Brown.
_____8. De-icing. h. Red-blue.

Answers to Frame 44: __f__ 1. __a__ 2. __d__ 3. __c__ 4. __e__ 5. __b__ 6.

Answer the following statements TRUE or FALSE.

_____1. The two most common types of tubing used in aircraft systems lines are corrosion-resistant aluminum alloy and copper.

_____2. Aluminum alloy tubing is most widely used in low and medium pressure systems.

_____3. The color code which identifies the contents of the system as breathing oxygen is red.

_____4. Stainless steel tubing is used in high-pressure systems.

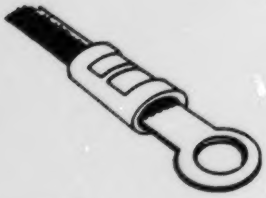
Answers to Frame 45: __g__ 1. __e__ 2. __d__ 3. __f__ 4. __c__ 5.

__h__ 6. __b__ 7. __a__ 8.

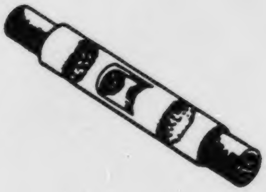
Frame 47

Electrical wires are terminated with solderless terminal lugs (A). Terminal lugs permit easy and efficient connection and disconnection from electrical equipment. Solderless splices (B) join electrical wires to form permanent continuous runs. These terminal lugs and splices come preinsulated (A) or uninsulated (B). They are made of copper or aluminum.

Note: Copper wire requires copper connectors and the aluminum wire requires aluminum connectors.



"A"



"B"

Select the correct statement(s).

____1. To join electrical wires to form a continuous run, solderless terminal lugs are used.

____2. Solderless terminal lugs permit easy disconnection and connection to electrical equipment.

____3. Solderless terminal lugs and solderless splices may be uninsulated or preinsulated.

Answers to Frame 46: __F__ 1. __T__ 2. __F__ 3. __T__ 4.

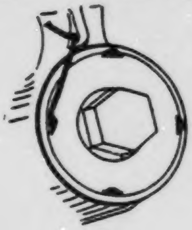
Aircraft vibration tends to loosen or alter adjustment of various parts. Therefore, parts are safetied by an auxiliary device such as safety wire.

Safety wire is available in either copper, aluminum or steel. Copper wire (.020-inch diameter), is used for safetying seals on equipment such as first aid kits and portable fire extinguishers.

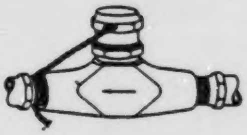
Aluminum wire (.032-inch diameter) is used for safetying emergency valves or oxygen regulators. BE SURE TO CONSULT THE SPECIFIC TECHNICAL ORDER AND USE THE WIRE REQUIRED.

Some emergency devices require installation of safety or shear wire. Particular care should be exercised to assure that the use of safety wire will not prevent emergency operation of the device.

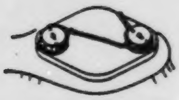
The following illustrations are typical examples of proper safety wire installations. Study these illustrations. Notice the proper procedures to follow in installing safety wire for a given situation.



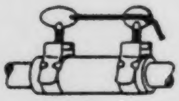
①



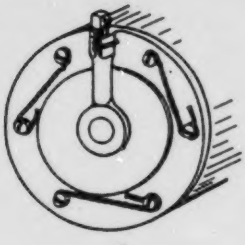
②



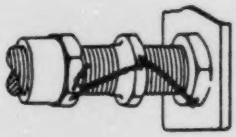
③



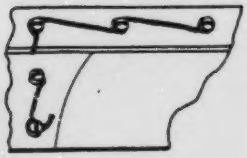
④



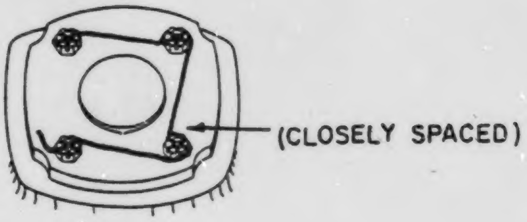
⑤



⑥



⑦



⑧

NO RESPONSE REQUIRED

Answers to Frame 47: ✓ 2. ✓ 3.

Frame 49

Two methods of safety wiring are used: the single-wire method and the double-twist method. The single-wire method is used on emergency devices. When using this method, be sure not to prevent its operation in case of an emergency. The signal-wire method is also used in areas hard to reach and for small screws in a closely spaced pattern.

The double-twist method is the most common method used. When using the double-twist method, .032-inch minimum diameter wire should be used on parts that have a hole diameter larger than .056-inch. Safety wire of .020-inch diameter (double strand) may be used as applicable on parts that have a hole diameter of .045-inch or less. The safety wire used should fill at least three-fourths of the hole.

Select the correct answer to the following statement.

1. The two sizes of safety wire most commonly used to safety parts, using the double-twist method, are

   a. .032-inch and .037-inch.

   b. .020-inch and .037-inch.

   c. .041-inch and .047-inch.

   d. .020-inch and .032-inch.

Answer to Frame 48: None Required.

The number of bolts, nuts, screws, etc., that may be wired together depends upon the application. When using the double-twist method, the maximum number of wider spaced bolts that can be wired in a series is three. When securing closely spaced bolts, the number that can be wired by a 24-inch length of wire is the maximum number in a series.

Select the correct answer for the statement below.

1. The maximum number of widely spaced bolts which may be wired in a series is

   a. 1.

   b. 2.

   c. 3.

   d. 4.

Answer to Frame 49: 1. d.

320 The correct procedure for safety wiring will be explained in the safety wiring project. In that project, you will learn the proper method by actually doing the job.

Answer to Frame 50: 1. c.

Note: To complete this frame, you must have access to a hardware trainer that has the names of the hardware items covered with tape.

Match the names below with the correct item on the trainer. Place the trainer number that corresponds with that item on the separate answer sheet. Some items on the trainer are not listed.

1. Wood washer.
2. Bolt, clevis.
3. Bolt, hex head steel.
4. Cotten pin.
5. Eyebolt.
6. Machine screw, flathead.
7. Screw, Reed and Prince head.
8. Lock washer.
9. Machine screw, roundhead.
10. Plate nut.
11. Machine screw, Fillister head.
12. Wing nut.
13. Nut, plain steel.
14. Screw, Phillips head.
15. Nut, castellated steel.
16. Bolt, drilled head steel.
17. Screw, sheetmetal.
18. Nut, self-locking aluminum.
19. Nut, steel self-locking.
20. Dzus stud.
21. Splice.
22. Elbow 90°, bulkhead.
23. Tinnerman nut.
24. Tee fitting.
25. Cross fitting, internal threads.
26. Elbow 90°, pipe to tube.

Answers to Frame 51:

1. 11.
2. 1.
3. 5.
4. 12.
5. 7.
6. 10.
7. 18.
8. 24.
9. 9.
10. 15.
11. 4.
12. 16.
13. 21.
14. 17.
15. 22.
16. 3.
17. 13.
18. 20.
19. 23.
20. 29.
21. 33.
22. 40.
23. 32.
24. 39.
25. 36.
26. 47.

PREPARE THE MAN

PROGRAMMED TEXT 3ABR42330-PT-515
3ABR32530-1-PT-809
3ABR34230-PT-903
3ABR32531-PT-~~108~~ 1058

Technical Training

Aircraft Electrical Repairman
Automatic Flight Control Systems Specialist
Flight Simulator Specialist
Avionics Instrument Systems Specialist

CARE AND USE OF HANDTOOLS

3 April 1974

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR42330-PT-515, 3ABR32530-1-PT-809, 13 April 1973.
OPR: TAS
DISTRIBUTION: X
TAS - 1200; TTOC - 5

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the Aircraft Electrical Repairman Course, 3ABR42330, and in the Automatic Flight Control Systems Specialist Course, 3ABR32530-1. The material was validated with 33 and 21 students from the respective courses. At least 90% of the students achieved the objectives as stated. The average time for completion of this text is 31 minutes.

OBJECTIVES

Without references, identify the proper care and use of handtools. A minimum of 70% accuracy is required.

INSTRUCTIONS

This programmed text presents information in small steps called frames. Carefully study the written material and schematic in each frame until you are satisfied that you understand its contents.

Each frame also requires you to respond to the information presented in various ways. For example, you may be required to select or complete true statements or match items to related situations. Specific instructions are contained in each frame. Check the accuracy of your work by checking the answer at the top of the next page. If your response is incorrect, study the frame again, and correct your error before continuing to the next frame. THIS IS IMPORTANT. You can more easily remember the material if you first read carefully and attempt to determine the correct answer, then check the accuracy of your response. DO NOT HURRY! The average time required to complete this text is 31 minutes.

Note: Record your answers on a Response Sheet which is attached to the back of this text. (Remove one copy.) When all response sheets have been used, then answers can be indicated on text itself.

FRAME 1

When you are assigned to an organization as a repairman you will be issued a toolkit. You must become familiar with the names, proper use, and care of the tools. Misuse of tools will result in damaged tools, accidents, or damaged aircraft equipment. Broken or damaged tools must not be used.

They must be turned in for new or serviceable tools.

The tools included in most toolkits are described in this text.

No response required.

FRAME 2

A ball peen is a steel hammer which should be used on hard metals, such as iron or steel. A plastic or brass hammer, sometimes called a mallet, should be used on soft metals or any soft materials that could be marred by a ball peen hammer. See figure 1.

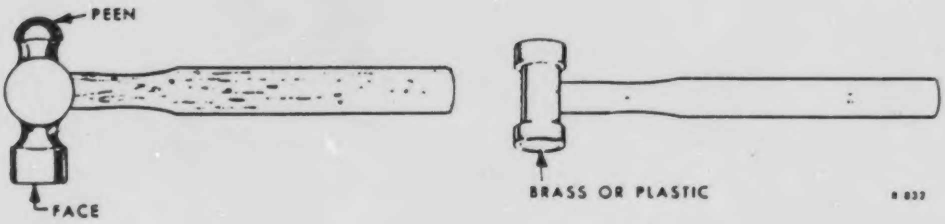


Figure 1.

Fill in the blanks of the following statements.

1. Use a ________________________ hammer to straighten an iron bar.

2. To bend a brass bar, use a ________________________ hammer or mallet.

Answers to frame 2

1. Ball peen 2. Brass or plastic

FRAME 3

When using a hammer, you should grip it near the end of the handle opposite the head. Strike the material squarely on its surface so the hammer will not glance and slide on the surface. Before using a hammer check its condition. It should have a tight handle, no cracks or grease on the head or handle and no mushrooming on the face of the head. If any defects are noticed, it should be repaired or turned in for a serviceable hammer. Cracked hammer handles cannot be repaired, they must be replaced.

Check the true statements.

1. _____A cracked hammer handle should be glued or taped before using.

2. _____If you can't repair a hammer, you should turn it in for a serviceable one.

3. _____While using a hammer, always hold it near the end of the handle.

328

Answer to frame 3

1. _____ 2. ✓ 3. ✓

FRAME 4

A common screwdriver has a flat tip. The size of the tip is determined by its width. See figure 2. The size of any screwdriver is determined by the length of the shank.

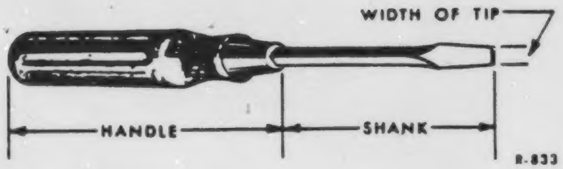
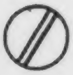


Figure 2.

Check the true statements.

1. _____To determine the size of a screwdriver, measure the width of the shank.

2. _____You should use a common screwdriver to tighten or loosen a screw with a head as in the illustration below.



3. _____A six inch screwdriver has a shank that is six inches long.

Answer to frame 4

1. _____ 2. __✓__ 3. __✓__

FRAME 5

Pointers concerning care and use of common screwdrivers are listed as follows:

1. Do not use a screwdriver for a pry bar, punch, or chisel.
2. When using a screwdriver, keep the shank perpendicular to the screw head.
3. Apply enough pressure on the screw to prevent the screwdriver from slipping out of the screw-head slot.
4. Use a screwdriver that properly fits the screw slot. See figure 3.
5. Do not use another tool to increase the leverage of a screwdriver. To do so may damage the screwdriver tip or screw slot. See figure 3.

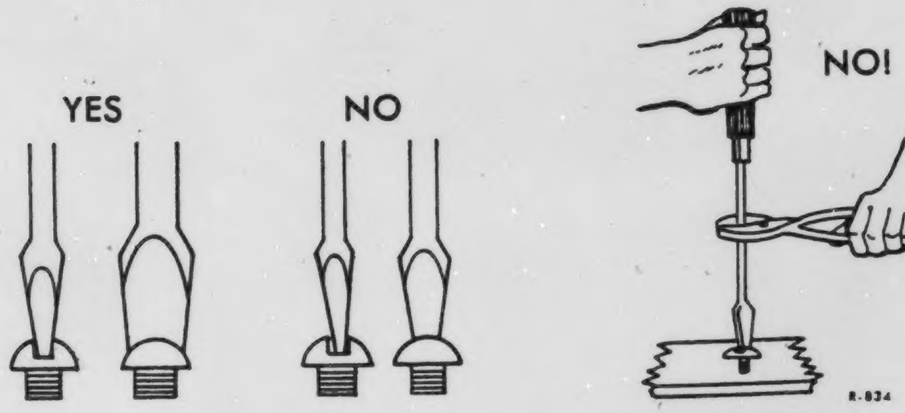


Figure 3.

Check the true statements.

1. _____If you cannot loosen a screw, you should use a longer screwdriver.

2. _____If a screwdriver doesn't fit the screw slot you should grind it to fit.

3. _____An important factor to consider when selecting a screwdriver for a particular screw is the size of the tip.

4. _____You should never use a wrench on a screwdriver.

Answer to frame 5

1. ____ 2. ____ 3. _✓_ 4. _✓_

FRAME 6

Two types of cross recess screwdrivers are the Phillips and the Reed and Prince. See figure 4. The phillips tip is blunt, and the Reed and Prince tip is pointed. Tips of cross recess screwdrivers vary in size so you must select the proper size tip to fit the mating slots in the screw head; however, the size of the screwdriver is determined by the length of the shank.

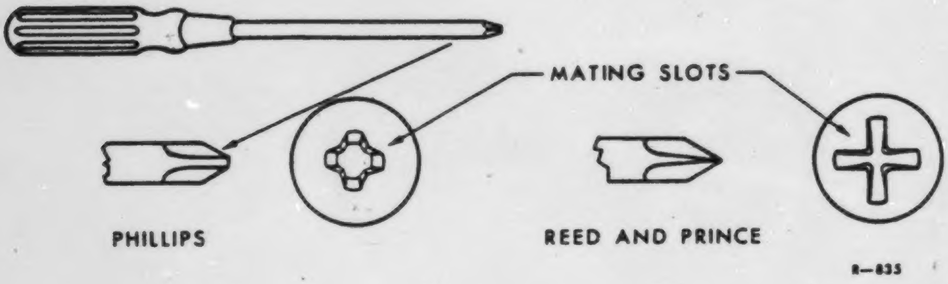


Figure 4.

Check the true statements.

1. _____If the shank of a cross recess screwdriver is ten inches long and its handle is four inches long, it is a ten inch screwdriver.

2. _____The main difference between a Reed and Prince and a Phillips screwdriver is the shape of their tips.

3. _____The Phillips screwdriver has a sharply pointed tip.

Answer to frame 6

1. ✓ 2. ✓ 3. ____

FRAME 7

The same do's and don'ts concerning the care and use of common screwdrivers applies to care and use of cross recess screwdrivers. One additional rule must be remembered, and that is to use the screwdriver designed for the screw recess. In other words, use only a Phillips screwdriver on a Phillips recess screw, and a Reed and Prince screwdriver, only on a Reed and Prince recess screw.

Check the true statements.

1. ____When using a cross recess screwdriver, you must keep the shank perpendicular to the screw head.
2. ____You should not use pliers to increase the leverage of a cross recess screwdriver.
3. ____All cross recess screwdriver tips are the same size.
4. ____A small common screwdriver should not be used in a cross recess screw.

Answer to frame 7

1. ✓ 2. ✓ 3. ____ 4. ✓

FRAME 8

An offset screwdriver has both ends bent as shown in figure 5. It is used to tighten or loosen screws in areas where longer screwdrivers will not fit. The two tips are placed at right angles to each other to aid screw removal in areas where turning area is limited. Both tips of an offset screwdriver are the same size. Select the offset screwdriver with tips that fit the screw slot.

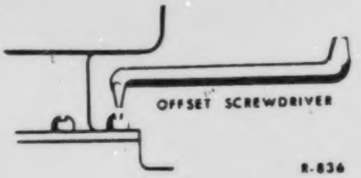


Figure 5.

Check the true statements.

1. ____An offset screwdriver may be used in a limited access area where a longer screwdriver cannot be used.

2. ____The two tips on an offset screwdriver are for use on different sized screw heads.

3. ____While using an offset screwdriver, you should hold the screwdriver so the tip is perpendicular to the screw head.

Answer to frame 8

1. __✓__ 2. _____ 3. __✓__

FRAME 9

A machinist's cold chisel is made of hard steel, and may be used for cutting cold metal. If possible, place the metal to be cut in a vise, and strike the cold chisel firmly and squarely, with a ball peen hammer. See figure 6.

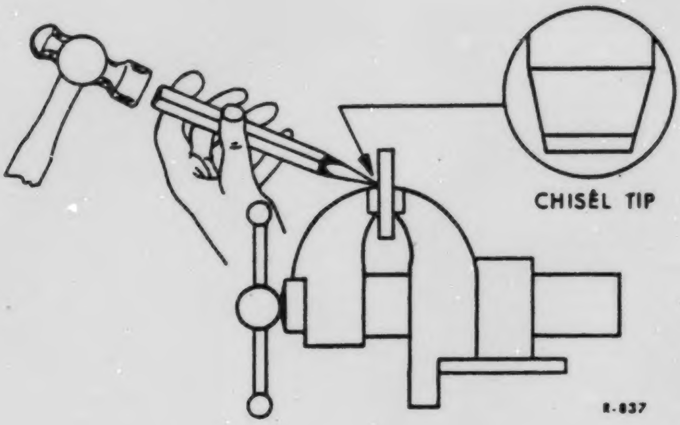


Figure 6.

Check the true statement or statements.

1. _____You should strike a cold chisel with a steel hammer.

2. _____Metal to be cut with a cold chisel should be hot before cutting.

Answer to frame 9

1. __✓__ 2. _____

FRAME 10

The cold chisel cutting edge must be kept sharp, and usually requires sharpening after each use. As the chisel is used, its head gradually becomes mushroomed, and should be dressed with a grinding wheel as shown in figure 7.

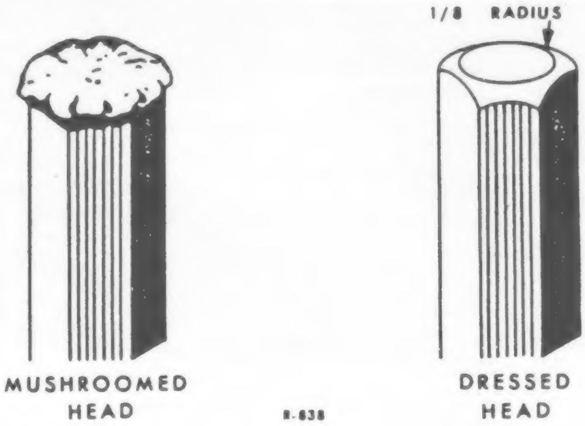


Figure 7.

Check the true statement or statements.

1. _____Cold chisels should be sharpened frequently.

2. _____Sharpening a cold chisel consists of grinding off the mushroomed head.

Answers to frame 10

1. ✓ 2. ____

FRAME 11

The electrical repairman's toolkit usually contains two types of punches, a center punch and a pin punch. See figure 8. A center punch is used to mark the location of holes to be drilled in metal. A pin punch is used to drive pins or rivets from holes in metal. Do not use a center punch to remove a pin or rivet from a hole as the sharp point may spread the pin and lock it in the hole.

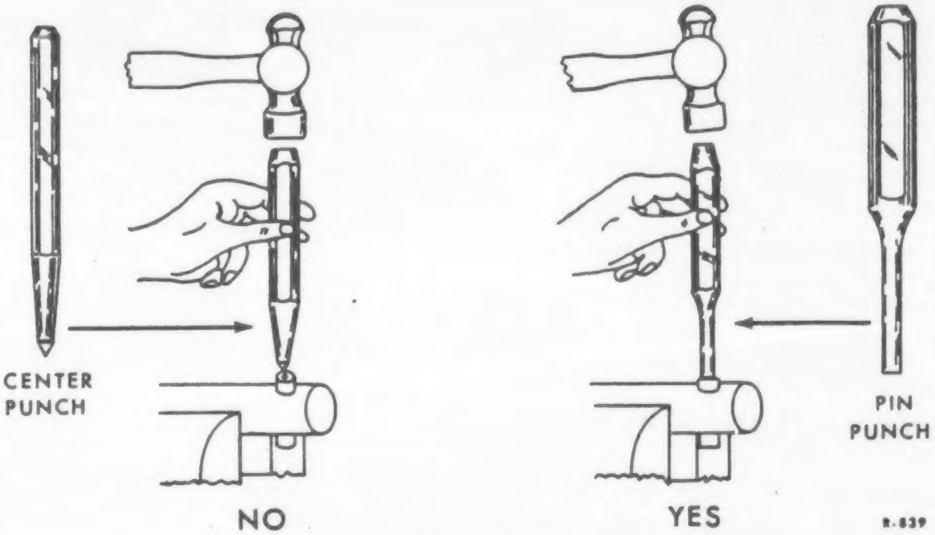


Figure 8.

Check the true statement or statements.

1. ____If you wished to drill a hole in a piece of soft steel you should first use a center punch.

2. ____You should use a pin punch to drive a broken cotter pin from a hole in a shaft.

3. ____A center punch should be used to drive a pin from a hole in metal.

Answers to frame 11

1. __✓__ 2. __✓__ 3. _____

FRAME 12

Files are used for smoothing or removing small amounts of metal. The four files illustrated below are used for the following operations:

1. A flat file is used for filing flat surfaces or edges.
2. A round file is used to enlarge round holes.
3. A taper file is used for various filing operations such as sharpening saw blades or filing small parts.
4. A half round file may be used on flat or concave (hollow and curved) surfaces or edges.

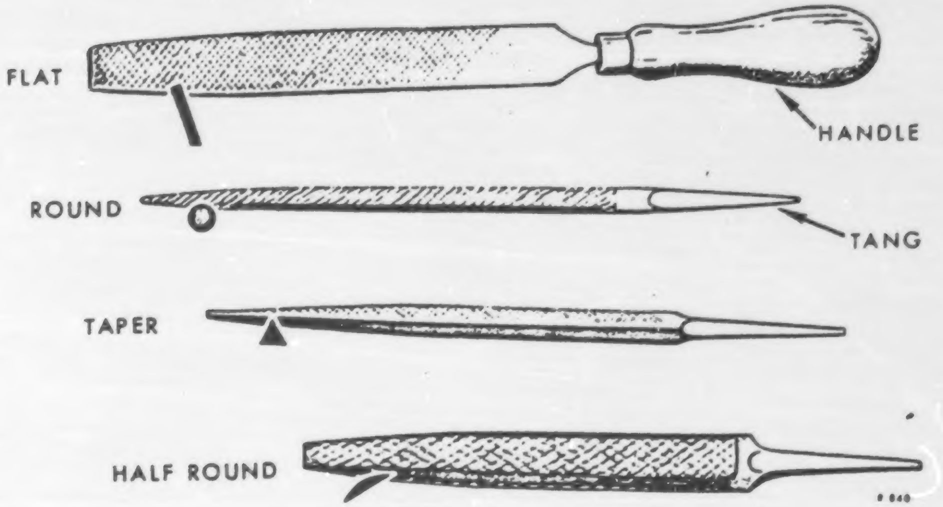


Figure 9.

Check the true statement or statements.

1. _____You should use a taper file for enlarging a round hole.

2. _____A half-round file should be used for filing a concave edge.

3. _____Use a flat file for removing a small amount of metal on a straight-flat edge.

4. _____The tang is the file handle.

Answers to frame 12

1. _____ 2. ✓ 3. ✓ 4. _____

FAME 13

If the metal to be filed is not too large, it should be held firmly in a vise. Use a long uniform forward stroke, and only enough downward pressure to keep the file cutting. See figure 10. Do not drag the file across the metal on the back stroke as this would dull the teeth. Lift the file on the back stroke. Before using a file, be sure it has a handle, otherwise, the sharp tang could injure your hand.

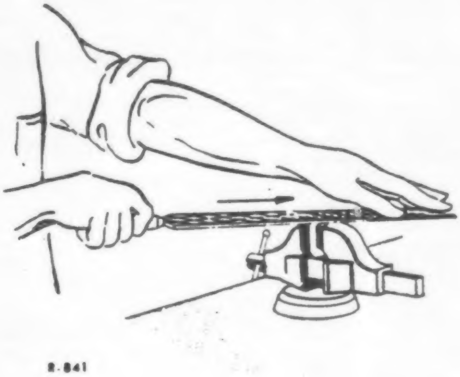


Figure 10.

Check the true statement or statements.

1. _____The file should contact the metal only on the forward stroke.

2. _____You should lift the file from the metal on the back stroke.

3. _____You do not need a handle on a large flat file.

Answer to frame 13

1. __✓__   2. __✓__   3. _____

FRAME 14

The cutting action of a file produces small chips or filings. Filings frequently wedge between the file teeth and reduce the cutting action. Clean a file by brushing with a wire brush, called a file card. See figure 11. Push the file card in a direction parallel with the file teeth. The reverse side of the card contains a fiber brush for brushing the file after carding. A metal pick may be removed from the handle of the file card to aid in removing metal filings that cannot be removed otherwise. After cleaning a file it should be wrapped in cloth or paper and placed in your toolkit. Wrapping protects the teeth.

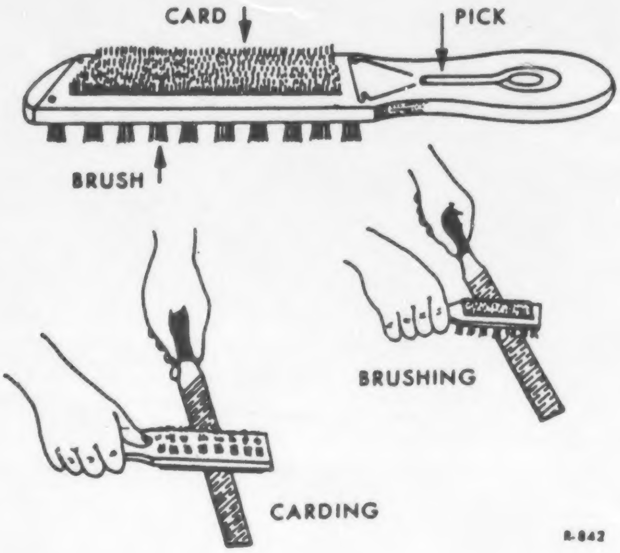


Figure 11.

Check the true statements.

1. _____To clean a file, use the card before the fiber brush.

2. _____Clean a file by pushing the card across the file teeth.

3. _____Files should be cleaned and wrapped after use.

Answer to frame 14

1. ✓   2. ______   3. ✓

FRAME 15

Some adjustable pliers are slip-joint, water-pump, vise-grip, and conduit pliers. See figure 12. Pliers increase hand leverage. They are used to firmly grip material while bending or twisting wire, holding round metal stock, or small diameter pipe, bending cotter pins, and other general purpose holding operations. The jaws of these pliers are adjustable so that various sizes of material may be securely held without excessive strain on the hand. Use the conduit pliers to loosen or tighten electrical conduit nuts and connectors. These pliers should not be used on bolt heads or nuts.

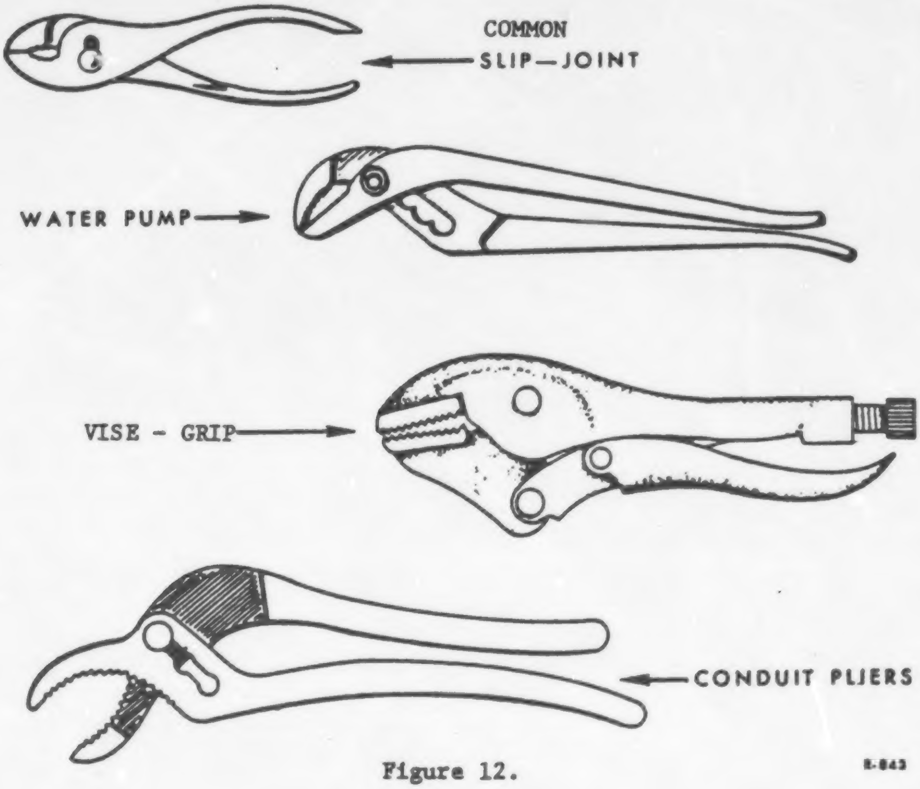


Figure 12.

Check the true statement or statements.

1. _____Pliers increase hand grip leverage.

2. _____Pliers have adjustable jaws so that various sized materials may be more conveniently held.

3. _____Conduit pliers have adjustable jaws.

Answer to frame 15

1. ✓ 2. ✓ 3. ✓

FRAME 16

Pliers may be used for many general operations but must never be used on nut and bolt heads. See figure 13. To do so may damage the nut or bolt, and may damage the plier jaw serrations. Pliers usually mar the surface of any material, so be careful when using these tools.

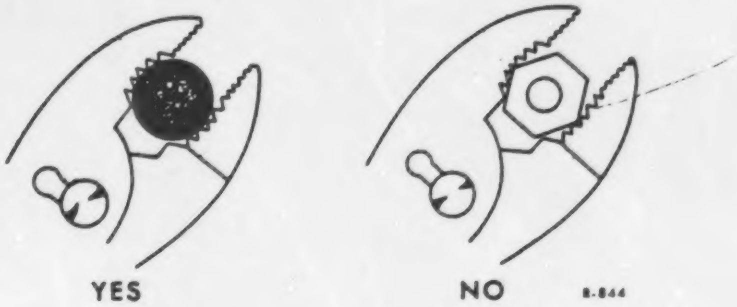


Figure 13.

Check the true statement or statements.

1. _____Pliers may be used to loosen a nut, provided you are careful.

2. _____Plier jaw serrations are sharp, and may damage any material on which they are used.

Answers to frame 16

1. _____ 2. ✓

FRAME 17

Electrical work requires the use of half-round-nose pliers, diagonal-cutting and duckbill pliers. See figure 14. These pliers do not have adjustable jaws. Half-round-nose pliers are used for bending and forming wire, holding wire during soldering operations, holding small parts, etc. Diagonal-cutting pliers are used for cutting such material as wire and cotter pins. Do not use diagonal-cutting pliers for cutting screws or small bolts. Use duckbill pliers for safetying bolts and nuts with safety wire, or removing safety wire.

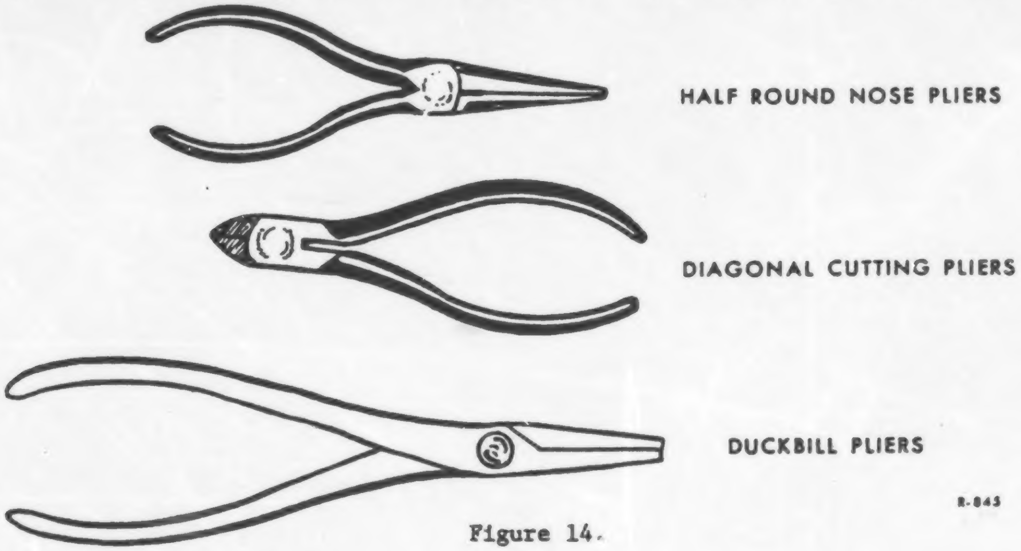


Figure 14.

Check the true statement or statements.

1. _____Diagonal-cutting pliers are mainly used for cutting electrical wire.

2. _____Half-round-nose pliers could be used during electrical soldering operations.

3. _____Duckbill pliers are better for removing safety wire than half-round-nose pliers.

Answers to frame 17

1. ✓ 2. ✓ 3. ✓

FRAME 18

A hacksaw may be used to cut metal such as soft-steel rod, bolts, and heavy-electrical cable. The material to be cut should be held securely, preferably in a vise. The blade is clamped in the saw frame, and may be replaced when dull or broken. Blades should be inserted in the frame so the teeth point forward. Cutting is done only on the forward stroke. See figure 15.

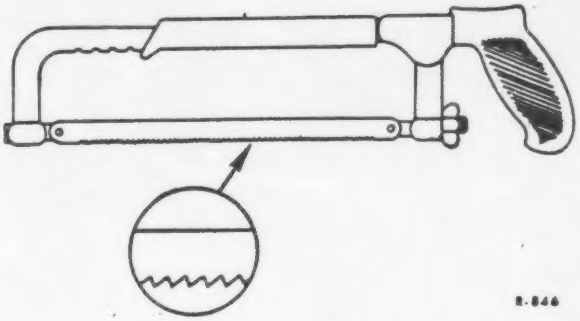


Figure 15.

Check the true statements.

1. _____Hacksaw blades are replaceable in the saw frame.

2. _____Small-electrical wires should be cut with a hacksaw.

3. _____It is possible to incorrectly insert a hacksaw blade in the saw frame.

Answers to frame 18

1. ✓ 2. _____ 3. ✓

FRAME 19

The correct and incorrect use of the hacksaw is illustrated below.

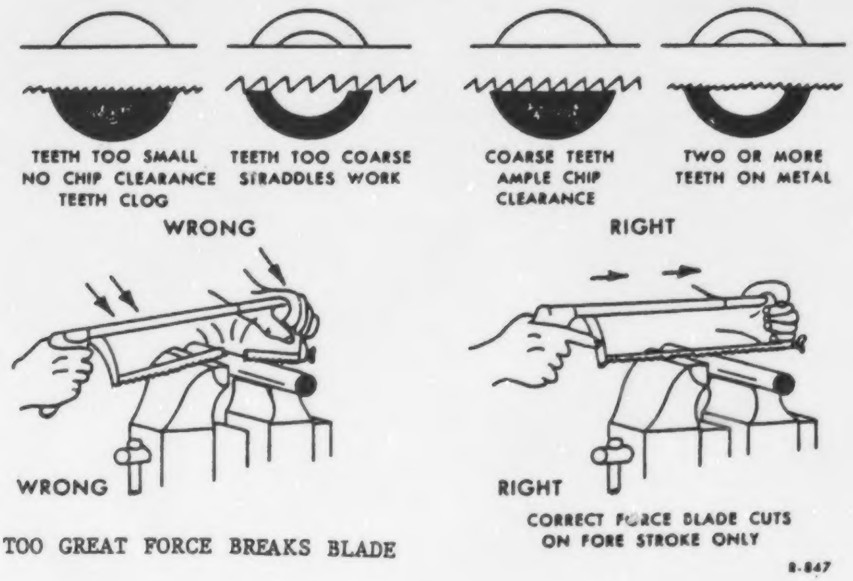

TEETH TOO SMALL NO CHIP CLEARANCE TEETH CLOG
TEETH TOO COARSE STRADDLES WORK
COARSE TEETH AMPLE CHIP CLEARANCE
TWO OR MORE TEETH ON METAL
WRONG
RIGHT
WRONG
RIGHT
TOO GREAT FORCE BREAKS BLADE
CORRECT FORCE BLADE CUTS ON FORE STROKE ONLY
8-847

Figure 16.

Check the true statements.

1. _____Most of the force you exert on a hacksaw should be downward.

2. _____You should select a hacksaw blade for the material you wish to cut.

3. _____A hacksaw blade only cuts on the forward stroke.

Answer to frame 19

1. _____ 2. ✓ 3. ✓

FRAME 20

Figure 17 is an illustration on a box-end wrench. Because of its strength, this is the best wrench for loosening a "tight" nut or bolt. Considerable force can be applied to the wrench without the danger of breaking the wrench or damaging the hex nut or bolt head.

Do not attempt to increase leverage on any wrench by placing a pipe or other wrench on the end of the wrench. The increased leverage could damage the wrench or bolt. Never strike the end of the wrench with a hammer while loosening or tighting a nut or bolt.

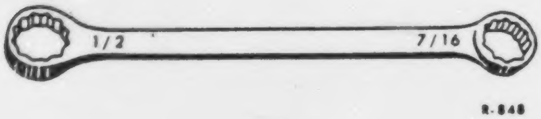


Figure 17.

Check the true statement or statements.

1. _____The box end wrench is used to loosen hex head bolts or nuts.

2. _____If greater force is needed, use a wrench extension.

Answer to frame 20

1. ✓ 2. ______

FRAME 21

The jaws of an open end wrench are placed at an angle to the handle. See figure 18. when the turning area is limited, you can turn the wrench over (upside down), after you reach the end of the turning area. Since force is exerted only on two faces there is a possibility of rounding or damaging a "tight" nut or bolt. The open-end wrench should not be used where it is possible to use box end wrenches.

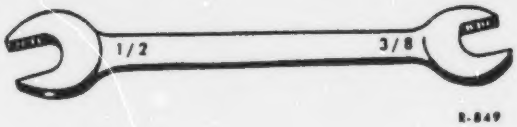


Figure 18.

Check the true statement or statements.

1. _____You should always use an open end wrench if it will fit.
2. _____Both jaws of an open end wrench are usually the same size.
3. _____You should never strike the end of an open end wrench with a hammer or other mechanical device.

Answers to frame 21

1. _____ 2. _____ 3. __✓__

FRAME 22

The adjustable-jaw wrench should only be used when no other wrench is available. If you must use this wrench, you should pull in the direction shown in figure 19A. If you apply force in the opposite direction, the adjustable jaw may break.

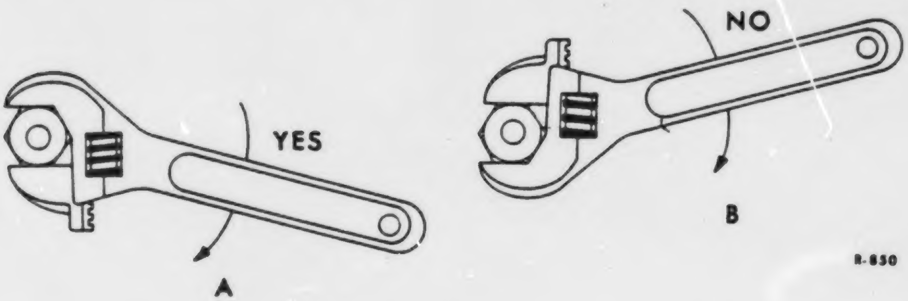


Figure 19.

Check the true statement or statements.

1. _____The adjustable-jaw wrench is the best wrench to use for removing most bolts or nuts.

2. _____Applying force in the direction shown in figure 19B is wrong because of the danger of breaking the wrench.

Answers to frame 22

1. _____ 2. __✓__

FRAME 23

Your toolkit will contain several sockets to fit various sizes of nuts. The sizes are stamped on the sides of the sockets. See figure 20. One end of the socket contains a square hole to receive the square drive on the socket handle.

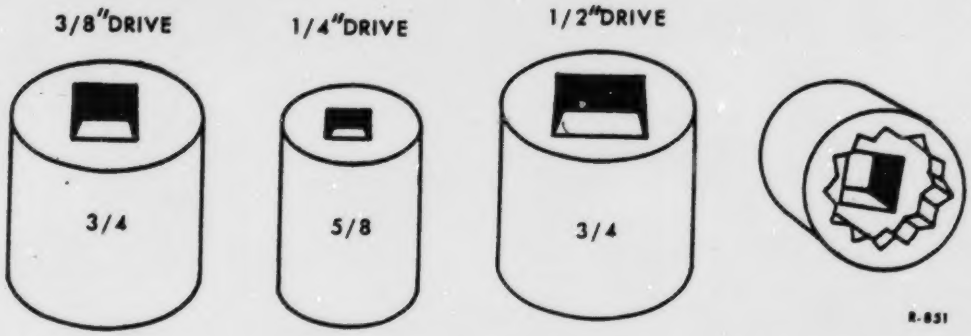


Figure 20.

Check the true statement or statements.

1. _____The socket-drive hole is the same size as the square drive on the wrench handle.

2. _____The number stamped on the socket refers to the size of the drive.

348

Answer to frame 23

1. ✓ 2. ____

FRAME 24

Some socket wrench handles and accessories are shown in figure 21. The hinge and "T" handle should be used to loosen or tighten a nut or bolt. The ratchet or speed handle should be used to remove or install a nut or bolt when little force is needed.

The socket extension may be placed between the socket, and any of the socket handles when turning area is restricted without the use of the extension.

Use a universal joint between the handle and socket when loosening or removing nuts or bolts in difficult access areas.

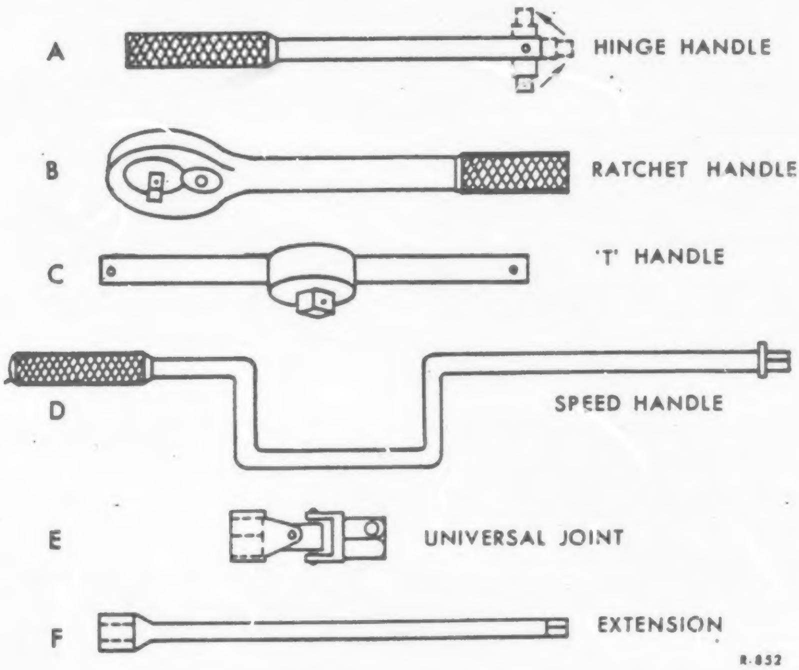

A
HINGE HANDLE
B
RATCHET HANDLE
C
'T' HANDLE
D
SPEED HANDLE
E
UNIVERSAL JOINT
F
EXTENSION
R-852

Figure 21.

Check the true statement or statements.

1. ____ When you use a socket you should use a hinge or "T" handle to loosen a "tight" nut.

2. ____ The socket extension should always be used with the ratchet handle.

370

Answer to frame 24

1. ✓ 2. _____

FRAME 25

The spin-tite wrench resembles a screwdriver handle with a socket on the shank. See figure 22. These wrenches, available in various sizes, are used to remove and replace small nuts on components and electrical terminal strips.

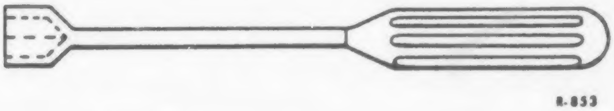


Figure 22.

Check the true statement or statements.

1. _____A ratchet handle could be installed on a spin-tite wrench.

2. _____A greater force could be applied with a spin-tite wrench than with a box-end wrench.

3. _____The socket on a spin-tite wrench cannot be removed from the shank.

Answer to frame 25

1. _____ 2. _____ 3. __✓__

FRAME 26

Torque wrenches are used to measure torque or twisting force that is applied to bolts and nuts while they are being installed. Some wrenches are designed to measure torque in inch pounds, others in foot pounds. There are two types of torque wrenches, the "T" handle and the automatic release or break-away type. One model of the automatic-release-torque wrench is shown in figure 23. To use it, place the correct sized socket on the square drive, and pull the handle until the wrench clicks or "breaks" away. The wrench should not be pulled after it clicks.

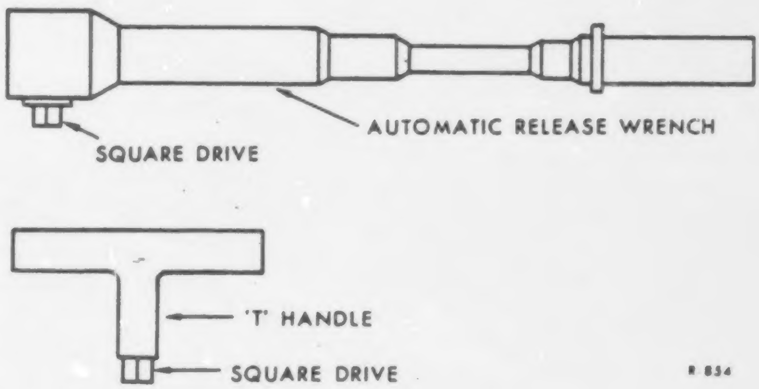


Figure 23.

Check the true statement or statements.

1. _____Torque wrenches only measure torque in foot pounds.

2. _____Torque wrenches are used to measure the twisting force applied to nuts or bolts.

3. _____You should use a torque wrench to loosen a nut.

4. _____Pull the automatic release handle to tighten the nut.

Answer to frame 26

1. _____ 2. ✓ 3. _____ 4. ✓

FRAME 27

The automatic-release-torque wrench has a micrometer on its handle. The micrometer consists of the shaft scale and vernier scale. Referring to figure 24, notice the shaft is graduated in 50 inch (or foot) pounds. The vernier scale is graduated from 0 to 50 inch (or foot) pounds. To increase the wrench torque setting, turn the grip clockwise. To reduce the torque setting, turn the grip counterclockwise. Turning the grip lengthens or shortens the handle.

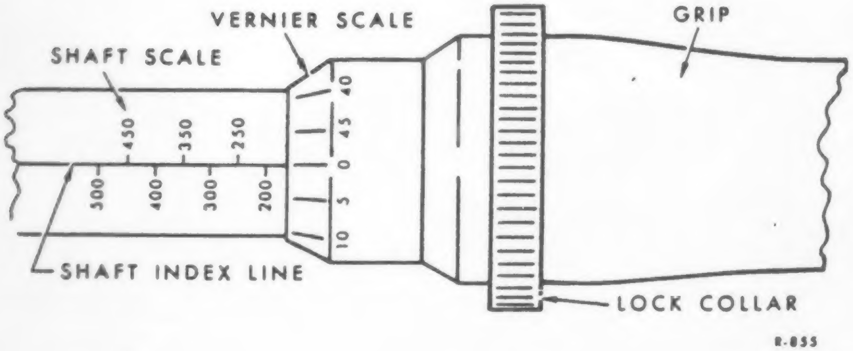

VERNIER SCALE
SHAFT SCALE
GRIP
450
350
250
500
400
300
200
40
45
0
5
10
SHAFT INDEX LINE
LOCK COLLAR
R-855

Figure 24.

Check the true statements.

1. _____The vernier scale is numbered from 0 to 50.

2. _____To increase the torque setting, the grip is turned counterclockwise.

3. _____The shaft is graduated in fifty inch (or foot) pounds.

Answers to Frame 27

1. ✓ 2. __ 3. ✓

FRAME 28

Torque wrenches should be handled like any other precision instrument. Each wrench has its own storage container, and should be calibrated (checked for accuracy) every 30 days. The dated tape on the wrench (see figure 25) indicates the date the wrench is due its next calibration. If the wrench is dropped, damaged, date tape is missing, or past due, the wrench must be recalibrated before it is used again.

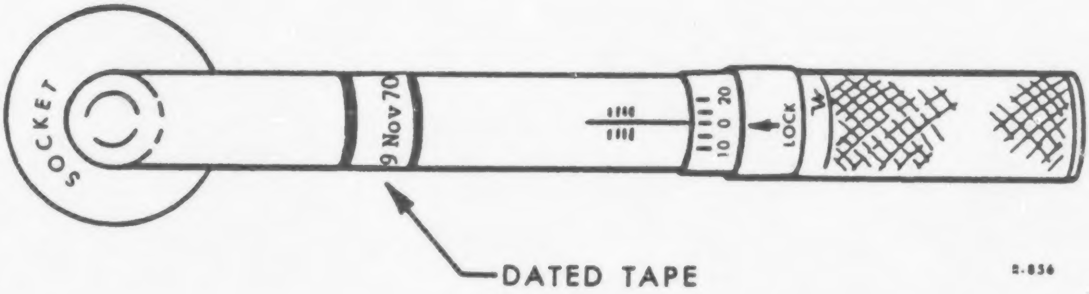


Figure 25.

Check the true statement or statements.

1. __ Torque wrenches should be calibrated every 30 days.

2. __ If a torque wrench is new, it need not be calibrated every 30 days.

3. __ Torque wrenches are precision measuring instruments.

Answers to Frame 28

1. ✓ 2. __ 3. ✓

FRAME 29

Adjustable torque wrenches should be stored at their minimum shaft scale setting. In other words, when you have finished using the wrench you should turn the grip counterclockwise to its lowest setting. This removes the tension from the spring in the handle. The accuracy of spring tension determines the accuracy of the wrench.

Check the true statement or statements.

1. _____ When you have finished using a torque wrench you should turn the grip counterclockwise to its lowest setting.

2. _____ The accuracy of a torque wrench is dependent upon the accuracy of its spring tension.

3. _____ When you finish with the torque wrench you should turn the grip to its minimum scale setting.

Answer to frame 29

1. ✓ 2. ✓ 3. ✓

FRAME 30

Wire strippers are used to remove insulation only from the ends of electrical wires. See figure 26. Several holes corresponding to various wire sizes are in the cutting edge of the tool. Care must be taken to insure that the correct hole is chosen for the wire being stripped. If the stripper hole is too small, some wire strands may be cut.

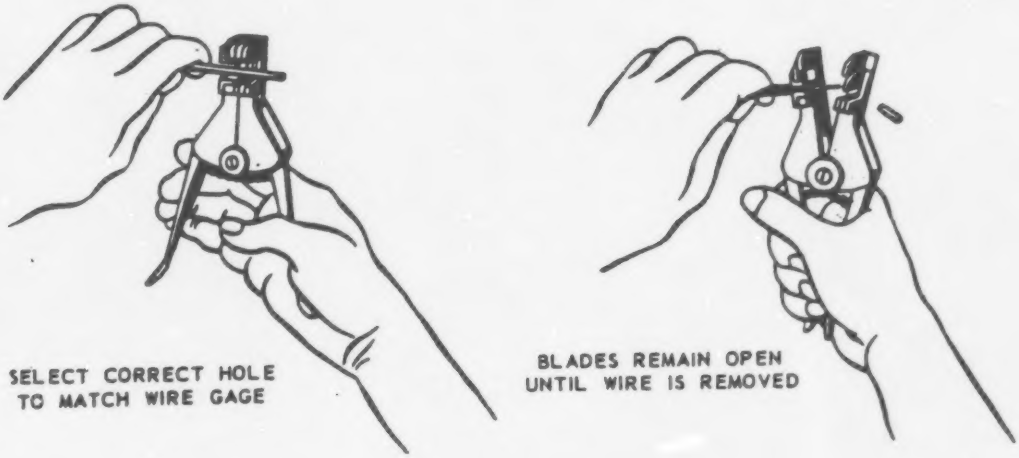

SELECT CORRECT HOLE
TO MATCH WIRE GAGE
BLADES REMAIN OPEN
UNTIL WIRE IS REMOVED

Figure 26.

Check the true statements.

1. _____There must be careful selection of the hole on the wire stripper for the wire size to be stripped.

2. _____The stripper should cut completely through the insulation.

3. _____A stripper is a handy tool for removing insulation from the center of a length of wire.

Answers to frame 30

1. ✓   2. ✓   3. _____

FRAME 31

You may use a pocket knife for stripping copper wire if no stripper is available. Care must be taken though, not to nick or cut the wire strands. A pocket knife is the only tool that should be used for stripping insulated aluminum wire. The knife must be used so as not to nick the wire. See figure 27. Nicks may cause the wire to break when there is vibration.

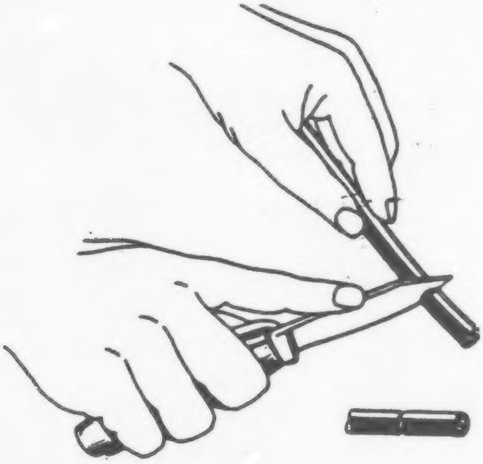


Figure 27.

Check the true statement or statements.

1. _____A pocket knife is the best stripping tool for all insulated wire.

2. _____A pocket knife may be used for stripping copper wire.

3. _____The stripper is not recommended for stripping insulated aluminum wires.

356

Answers to frame 31

1. _____ 2. __✓__ 3. __✓__

FRAME 32

The crimping tool illustrated in figure 28 should be used for connecting (crimping) preinsulated terminals to conductors. Other crimping tools such as Stakon pliers should be used to crimp noninsulated terminals. The insulation on the terminals is color coded according to the size of the conductors to which they are to be joined. The instruction plate on the crimper indicates which of the nests should be used for various sizes of wire.

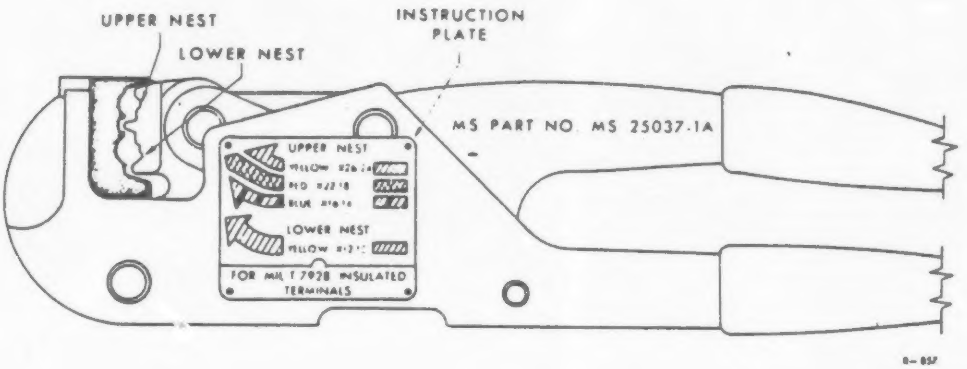

UPPER NEST
LOWER NEST
INSTRUCTION PLATE
MS PART NO. MS 25037-1A
UPPER NEST
YELLOW #26-24
RED #22-18
BLUE #16-14
LOWER NEST
YELLOW #12-10
FOR MIL T 7928 INSULATED TERMINALS
B-857

Figure 28.

Check the true statement or statements.

1. _____Preinsulated terminals can be crimped to a conductor.

2. _____Noninsulated terminals can be crimped to a conductor.

3. _____The instruction plate on the crimper indicates the pressure needed to crimp terminals to wires.

378

Answers to frame 32

1. ___✓___ 2. ___✓___ 3. _____

FRAME 33

Check the true statements.

1. _____A plastic mallet should be used to bend or form hard metal.
2. _____A ball peen hammer should be used on soft metal.
3. _____You should not attempt to repair a broken hammer handle.
4. _____You should not use a hammer with a loose handle.
5. _____You determine the size of a screwdriver by measuring the length of its shank.
6. _____You should select a screwdriver according to the size and type of screw recess.
7. _____A screwdriver can safely be used as a chisel or pry bar.
8. _____A screwdriver should not be used as a pry bar or punch.
9. _____You should never use a pocket knife for stripping electrical conductors.
10. _____If you cut some wire strands with a stripper, you have used a stripper hole that is too large.
11. _____Both tips of an offset screwdriver are the same size.
12. _____Cold chisels should be frequently sharpened.
13. _____A center punch has a sharp point.
14. _____You should use a ball-peen hammer and center punch to drive a rivet from its hole.
15. _____The sharp end of a file is called a tang.
16. _____Round holes should be smoothed with a flat file.
17. _____A vise-grip pliers is the best tool to loosen a tight nut.
18. _____Conduit pliers are adjustable.
19. _____Diagonal pliers should be used to cut small screws and bolts.
20. _____While using the hacksaw, most of the force you exert should be downward, on the blade.
21. _____You should use a large toothed hacksaw blade when cutting thin metal.
22. _____An open-end wrench should not be used where it is possible to use a box-end wrench.
23. _____A crimping tool is used to remove a terminal from a conductor.
24. _____The number stamped on a socket refers to the size of nut the socket fits.
25. _____The square hole in a socket fits on the nut.
26. _____The ratchet handle can be used to drive in both directions.
27. _____The ratchet handle is designed to be used in close quarters.
28. _____A spin-tite wrench is the best tool for removing nuts on electrical terminal strips.

29. _____ Torque wrenches only measure torque in inch pounds.
30. _____ Torque wrenches should be calibrated every two weeks.
31 _____ If you drop a torque wrench, you should have it calibrated before reusing it.
32. _____ When you have finished using a torque wrench you should turn the grip fully counterclockwise.

If you missed any of the above statements, restudy the relevant material in this text.

Answers to Frame 33

1. _____
2. _____
3. ✓
4. ✓
5. ✓
6. ✓
7. _____
8. ✓
9. _____
10. _____
11. ✓
12. ✓
13. ✓
14. _____
15. ✓
16. _____
17. _____
18. ✓
19. _____
]0. _____
21. _____
22. ✓
23. _____
24. ✓
25. _____
26. ✓
27. ✓
28. ✓
29. _____
30. _____
31. _____
32. ✓

WORKBOOK

3ABR32632B-WB-204
3ABR32530-1-WB-105
3ABR32531-WB-105

Technical Training

Integrated Avionic Systems Specialist
Automatic Flight Control Systems Specialist
Avionic Instrument Systems Specialist

MAINTENANCE FUNDAMENTALS
SPECIAL TOOLS, SAFETYING DEVICES, SOLDERING TECHNIQUES AND SOLDERLESS CONNECTORS

28 March 1978

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DESIGNED FOR ATC COURSE USE
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3ABR32530-1-WB-105
3ABR32531-WB-105

SECTION A

USING THE TORQUE WRENCH

OBJECTIVES

Given a handtool trainer, handtools, and torque wrench, torque bolts to specified values in accordance with procedures listed in Section A of the workbook. All of the responses must be answered correctly (100%).

EQUIPMENT

	Basis of Issue
Torque Wrench	1/student
Proper size socket and hinge handle	1/student
Trainer	1/student

PROCEDURE

At various places in this section you will be required to respond by answering questions or by following instructions and making comparisons.

Caution: Remove your jewelry before starting this lab.

1. Ask the instructor to assign you a trainer and the tools required. Check the equipment list to determine that you have all the tools required.

2. Remove the torque wrench from its case, check its verification due date. Is it overdue verification? (Yes)(No)

3. Look at the torque wrench shaft scale and fill in the blank.

   a. The torque wrench measures torque values in ________________ pounds.

4. The locking device on the wrench handle locks the grip so the torque setting cannot accidentally change as you use the wrench. To unlock your wrench, the lock must be:

   a. turned to the right (CW).

   b. pulled toward the rear on the hand grip.

OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 200; TTVSA - 1

Note: Before you can lock the grip you must center a vernier scale index (0, 5, 10, 15, 20, etc.) exactly on the shaft index line. If these two indexes are not aligned perfectly, the locking device cannot be placed in the lock position.

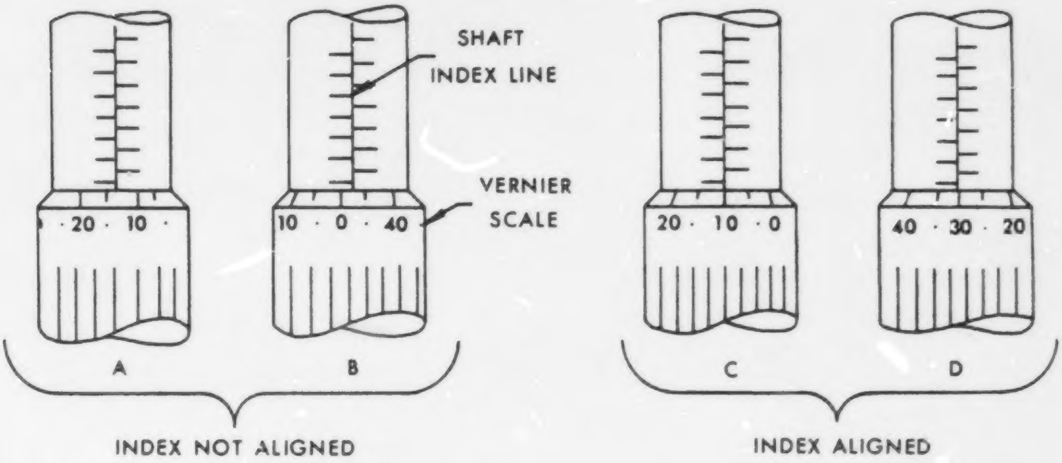


Figure 1. Torque Wrench Scales.

5. Adjust the torque wrench grip as shown in figure 1A, then try to lock the grip.

a. Could you lock the grip? (Yes)(No)

6. Adjust the torque wrench grip as shown in figure 1B and try to lock the grip.

a. Could you lock the grip? (Yes)(No)

7. Adjust the grip as shown in figure 1C and try to lock the grip.

a. Could you lock the grip? (Yes)(No)

8. Adjust the grip as shown in figure 1D and try to lock the grip.

a. Could you lock the grip? (Yes)(No)

9. Rotate the hand grip clockwise until the forward edge of the vernier scale is aligned with the 200 on the shaft. The "0" of the vernier scale will be aligned with the shaft index line. The wrench is now set to "breakaway" at exactly 200 inch-pounds.

10. Lock the grip at exactly 200 inch-pounds; this will prevent a change in the setting as you use the wrench.

11. Attach the socket to the square drive on the end of the torque handle.

Caution: Do not use the wrench until properly briefed by your instructor.

12. Call the instructor to check your setting. You will be told what bolts you are to torque and the instructor will demonstrate the proper use of the wrench.

13. Position yourself near the trainer so you can comfortably reach the bolts the instructor told you to torque.

14. Finger tighten all bolts until they are SNUG.

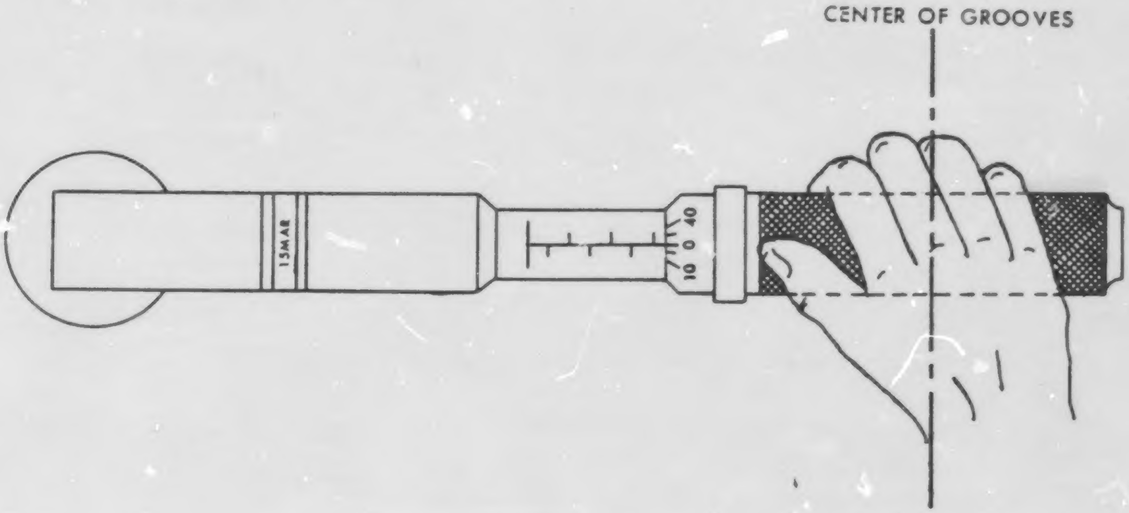


Figure 2.

15. Holding the torque wrench as shown in figure 2 and using a steady, smooth pull, pull the handle toward you until you reach the torque setting. When you reach the correct torque, the handle will click. This is known as "breakaway." (It feels like the wrench has slipped.) DO NOT PULL BEYOND THIS POINT. The click indicates the bolt has been torqued to 200 inch-pounds.

16. Torque the other bolts you were instructed to use in the same manner.

17. After torqueing all the bolts, remove the socket from the torque wrench. Place it on the hinge handle and loosen the bolts you just finished torqueing.

18. Pick up the torque wrench and unlock the handle grip.

19. Turn the grip back until the 150 inch-pound index is exposed, then set the grip to exactly 175 inch-pounds, (figure 3). After you have done this, check the illustration below to see if your handle setting is exactly the same; 150 on the shaft scale plus 25 on the vernier scale = 175 inch-pounds.

20. Lock the grip. Place the socket on the square drive.

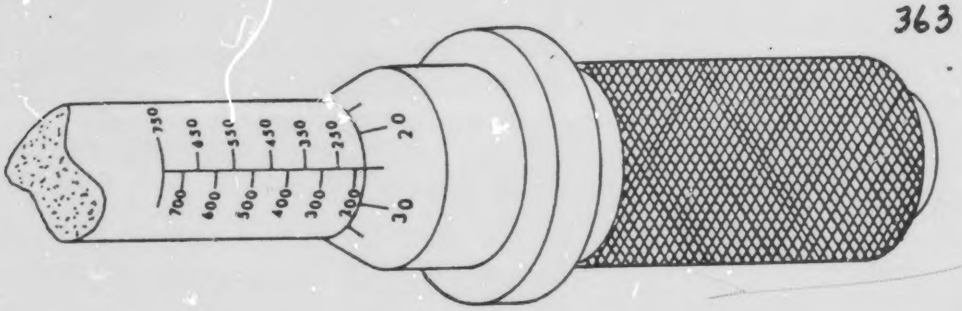


Figure 3.

21. Have the instructor check your setting before torqueing any bolts.

22. Torque the bolts designated by the instructor to the breakaway point (175 inch-pounds). You may go back to any step in this project that will clear up any doubts you have.

23. Loosen the bolts using the hinge handle and socket.

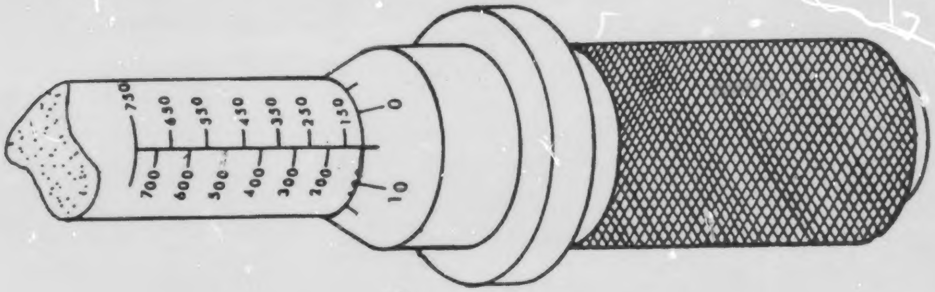


Figure 4.

24. Using the procedure, steps 16 through 19, set the wrench at 105 inch-pounds. Check the accuracy of your setting by referring to the illustration below (figure 4).

25. Have the instructor check your setting before torqueing any bolts.

26. Torque the bolts designated to exactly 105 inch-pounds.

27. You now have correctly torqued the bolts at three different settings and in each case using the proper procedures. Did you recognize that there is a difference in pull required for each setting? (Yes)(No)

28. Using the socket and hinge handle, loosen the bolts you torqued on the trainer.

29. Remove the socket from the hinge handle and place on the bench.

30. Set the torque handle to its LOWEST INDICATED SETTING. This is important since it relieves the tension on the handle's internal mechanism.

31. Inform the instructor that you have completed this project and have him check the setting on your wrench.

32. Put the torque wrench back in its protective metal case and place on the table with the hinge handle and socket.

33. Proceed to the next page and start your safety wiring projects.

SECTION B

SAFETYING DEVICES

OBJECTIVES

Given a handtool trainer, handtools and materials, accomplish safetying projects in accordance with procedures listed in Section B, projects I, II, III, IV and V of the workbook. All of the responses must be answered correctly (100%).

EQUIPMENT

	Basis of Issue
Steel safety wire .032"	As required
Copper safety wire .020"	As required
Trainer, safety wire	1/student
Diagonal cutter	1/student
Duckbill pliers	1/student
Cotter key	As required
Safety goggles	1/student

PROCEDURE

You will be required to follow each step in the text. You will make a check (✓) indicating completion of each step.

Caution: You are required to wear safety goggles during this entire project. Exercise extreme caution during this exercise to prevent cuts by sharp safety wire ends.

PROJECT I

In Section A you learned to torque bolts to insure uniform tightness. Now you will follow directions to safety different items to insure they do not vibrate loose during operation and cause system failure.

Put on the safety goggles. Read each step to determine what you are to do, then complete that part of the project. In Project I you will safety wire three bolts using the double twist method.

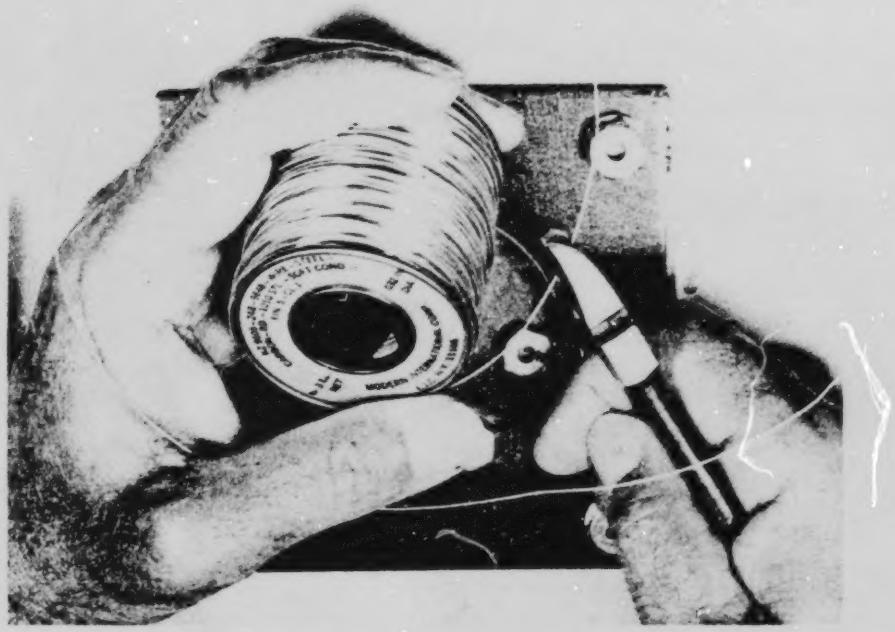


Figure 5.

_____1. Cut a piece of .032 steel safety wire approximately 3-1/2 times the length to be safetyed. DO NOT EXCEED 24 INCHES.

Caution: Observe how the spool of wire is held so the wire will not spring out around the spool, or spring up and hit you in the eyes while you are cutting the wire. This is one reason you are required to wear the safety goggles while working with safety wire.

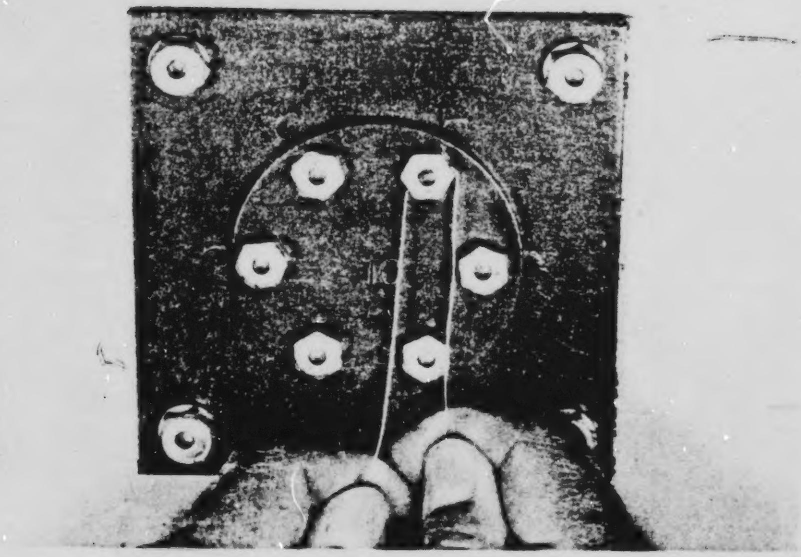


Figure 6.

_____2. Thread the wire through the hole in the bolt head until the wire on both sides of the bolt head is of equal length. Thread the wire so that it will become more taut if the nut starts to loosen.

Caution: When using the duckbill pliers, make certain you always grasp the tip of the wire. Using pliers at any other point on the wire nicks the wire, and causes it to become weak at that point.

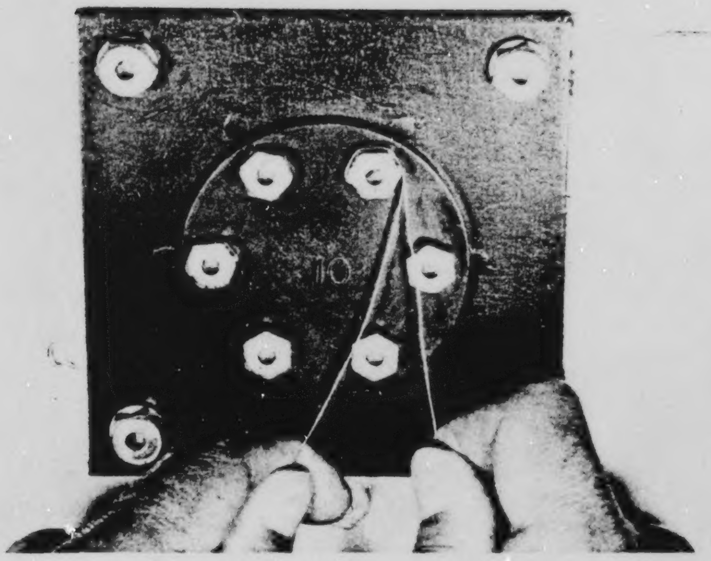


Figure 7.

_____3. Pull the left end of the wire around the bolt head in a clockwise direction, and under the right-hand wire. Pull tightly with the duckbill pliers so that the wire conforms to the shape of the hex head bolt.

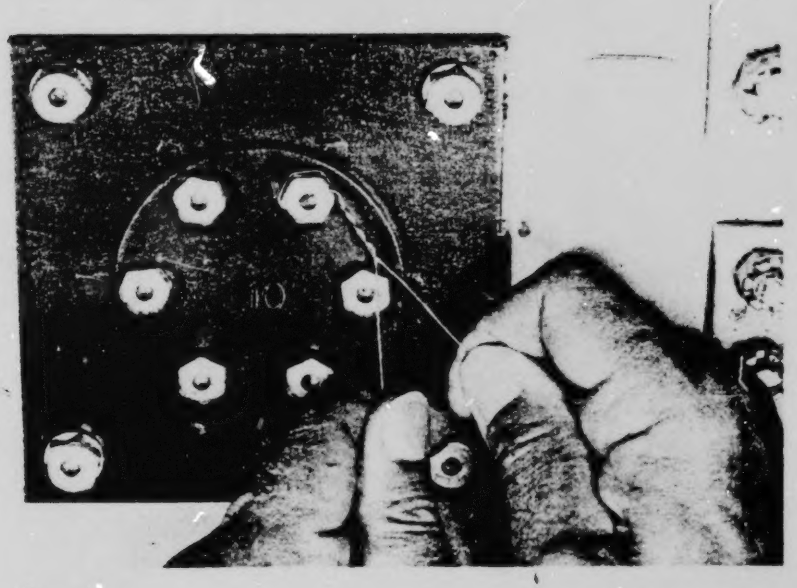


Figure 8.

____4. Pull the two ends 90° to the hole in the bolt head, and twist in a clockwise direction. Be sure that the first twist begins at the drilled hole. Make three twists at this angle while pulling firmly. Twist the wire together so that it is tight but do not overstress the wire. It may break under load or vibration.

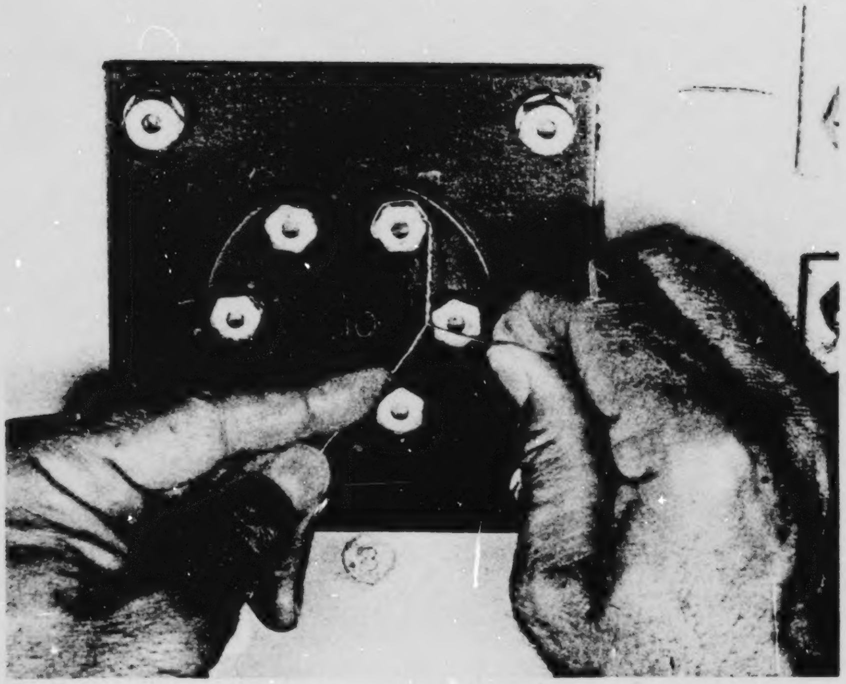


Figure 9.

_____5. Continue twisting and pulling in the direction of the next bolt until the twist reaches the closest hole on the left side of the nearest bolt head. The top wire should be one twist short of the hole in the bolt head before inserting the wire. If the twisted part of the wire is too short, make one more twist, and check for the correct length.

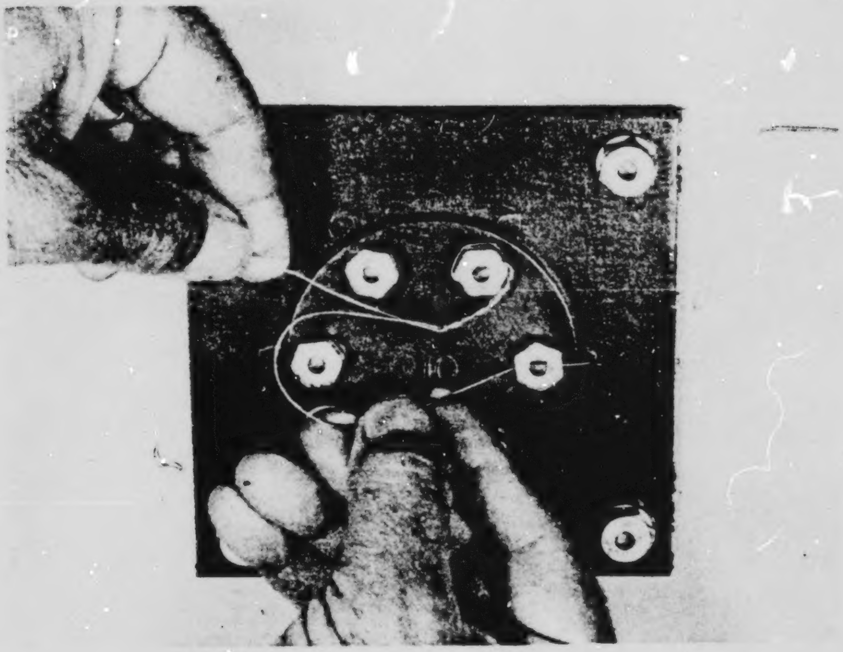


Figure 10.

_____6. Pull the bottom wire away from the second bolt head with the left hand, and insert tip of the top wire through the hole in the bolt head.

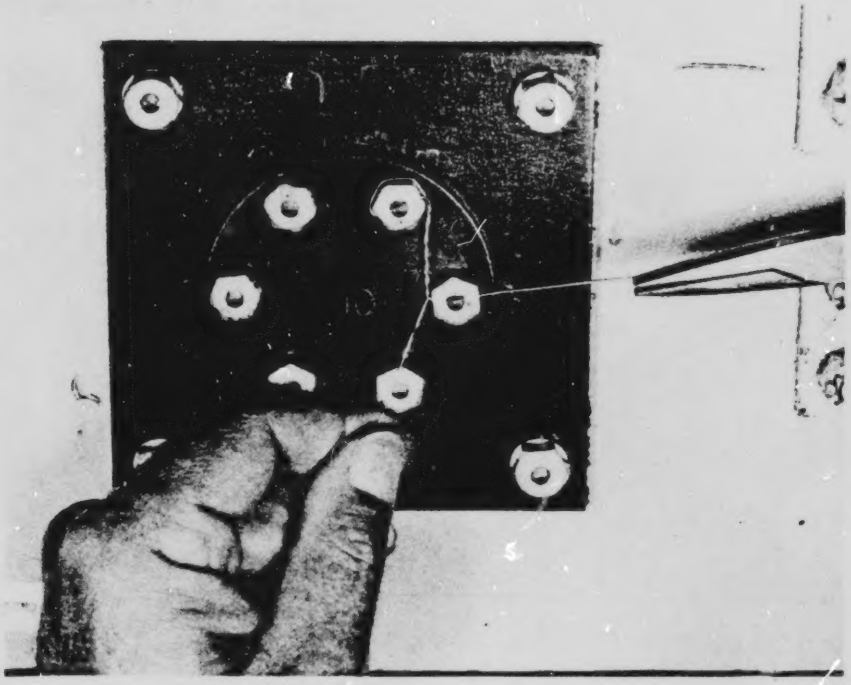


Figure 11.

_____7. Grasp the tip of the wire with the duckbill pliers, and pull it through the hole until the twisted part of the wire between holes is tight.

Caution: If you pull too tightly, the wire may break. Do not allow the right wire to kink as you pull.

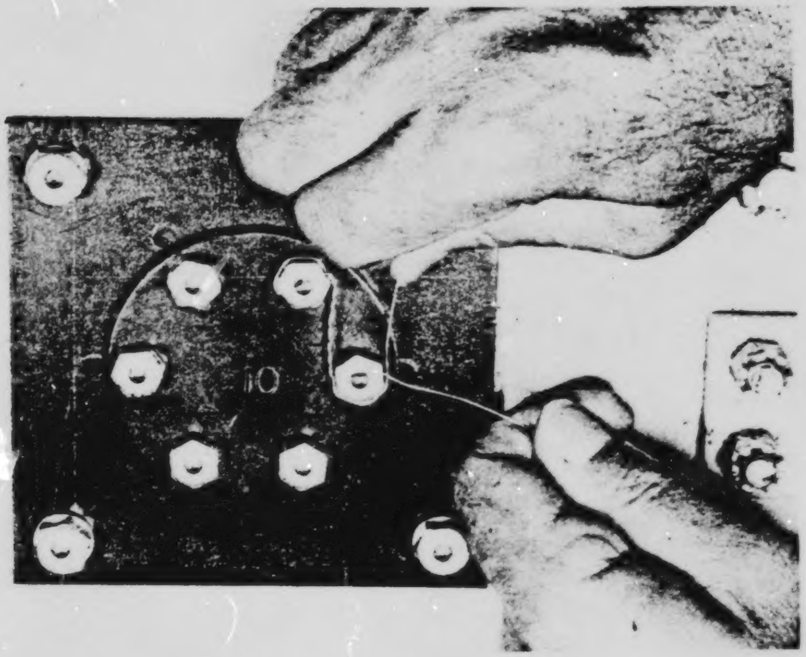


Figure 12.

____8. While keeping tension on the wire extending through the hole in the bolt, pull the other wire snugly around the bolt in a counterclockwise direction, and pass it under the wire extending through the hole in the bolt head.

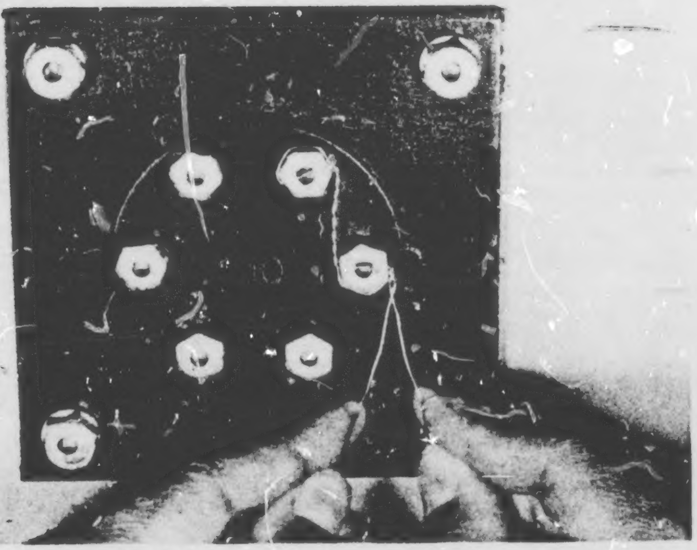


Figure 13.

____9. Pull the ends of the wire 90° (at a right angle) to the hole in the second bolt, and twist the wire in a counterclockwise direction. Be sure the first twist begins at the hole in the hex head.

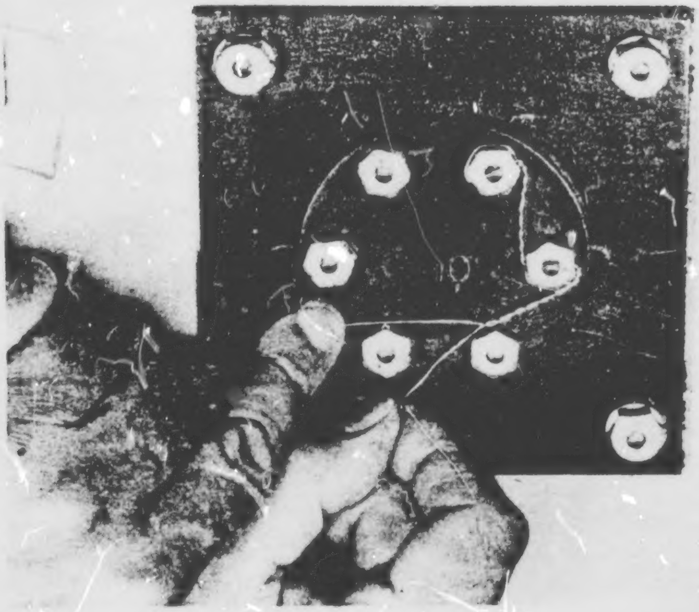


Figure 14.

____10. Continue twisting the wire and pulling it toward the next bolt. The top wire should be one twist short of the hole in the bolt. If this twist is too far from the hole, twist the wire once more. Constantly check the length so that you will not get it too long.

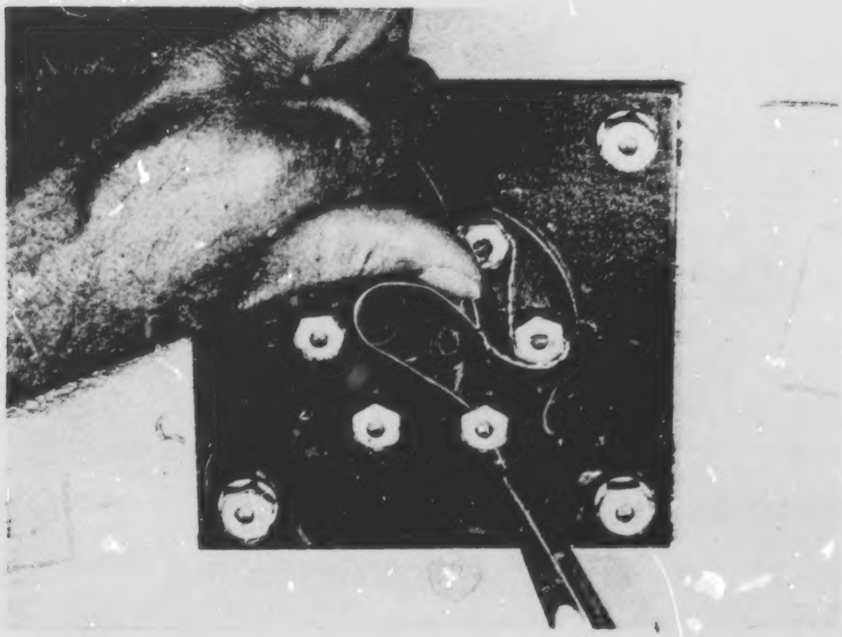


Figure 15.

____11. Pull the wire away from the second bolt head, and insert the bottom wire through the hole in the third bolt.

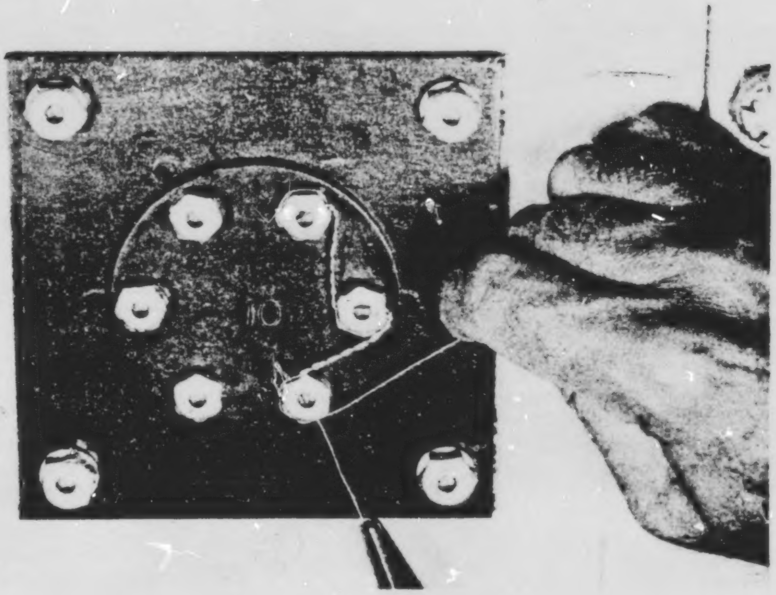


Figure 16.

____12. Pull the left wire snugly around the bolt head in a counterclockwise direction, and under the other wire. Twist the wire counterclockwise at least five turns.

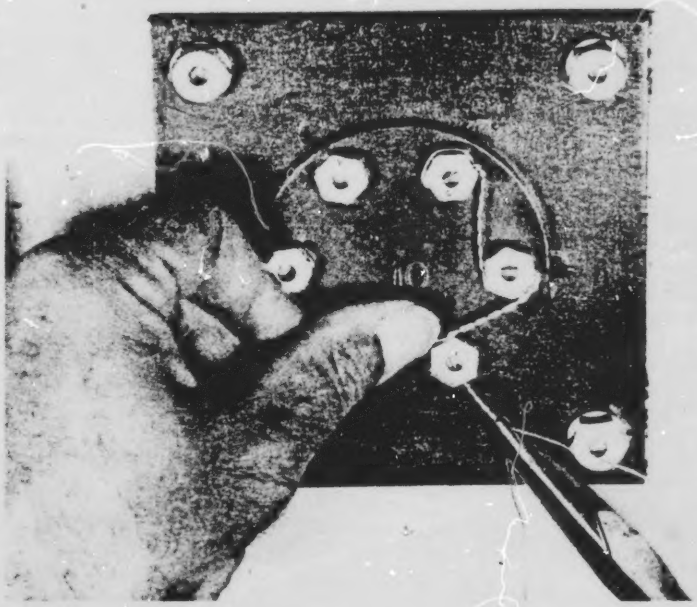


Figure 17.

____13. Use the duckbill pliers for the final twists of the wire for the purpose of applying tension. Twist wires together 3/4 to 1 inch away from bolt.

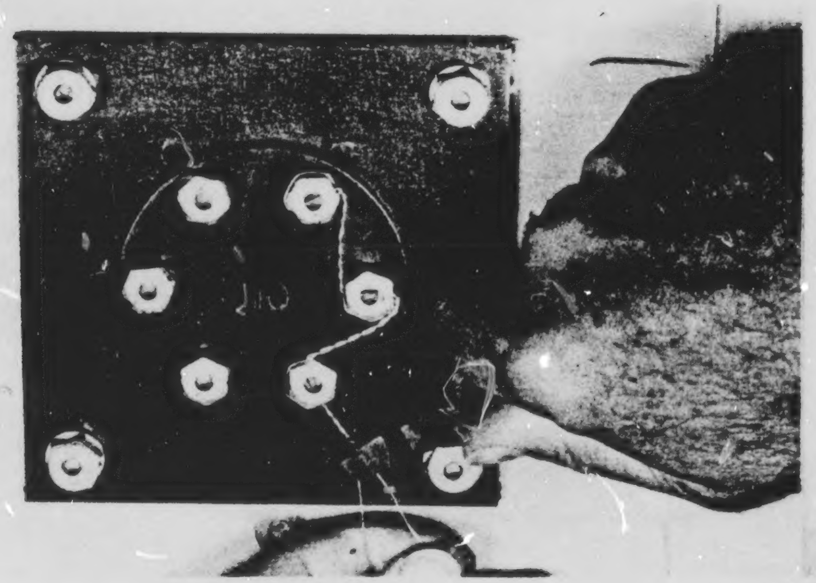


Figure 18.

____14. Cut the twisted wire 1/4 to 1/2 inch from the bolt head, this leaves the two ends of the wire twisted together and easy to keep hold of.

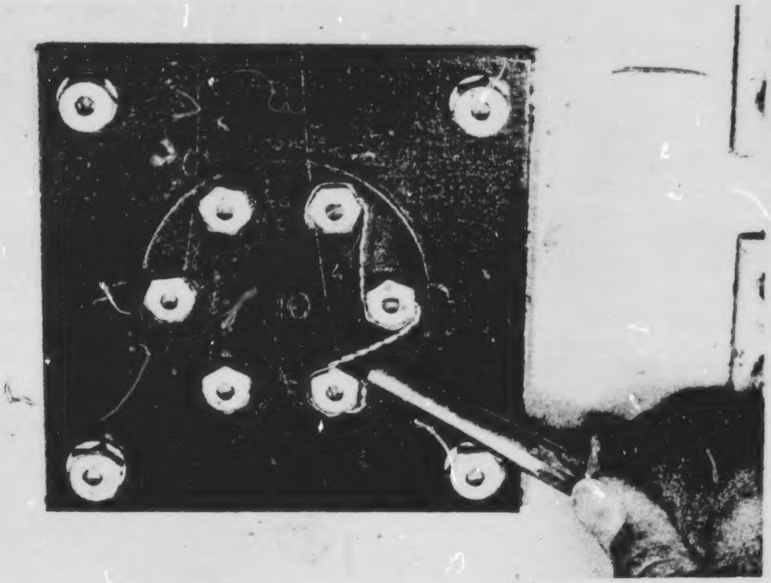


figure 19.

____15. Using the duckbill pliers, bend the end of the twisted wire counterclockwise around the bolt head so that the sharp ends will not snag.

____16. Your safetying job is finished. It should look like the illustration above. Ask your instructor to check your work.

____17. If necessary, resafety the opposite three bolts for practice, and again have your instructor check your work.

Instructor's Signature ______________________________

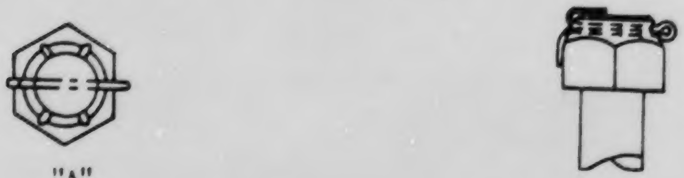
____18. Remove the safety wire from the trainer and clean up all the scraps and place in metal trash can (foreign object container).

Note: When removing safety wire always try to cut to keep all pieces of wire twisted together in one piece. One small piece of wire lost in the aircraft could cause a short and possible loss of the aircraft.

Have the instructor show you which bolt you are to use for Project II, Cotter Key Installation.

PROJECT II

INSTALLATION OF COTTER KEY



"A" "B"

Figure 20.

Observing A and B, in figure 20, place a cotter pin in the nut and bolt on the trainer by following the steps listed below.

The following procedures will guide you in this operation. Place a (✓) on the blanks as you perform the steps.

_____1. Insert the cotter pin in the hole in the bolt.

_____2. Bend the ends of the cotter pin slightly. Hold the cotter pin so that it will not be forced back in the hole.

_____3. Cut the end of the cotter pin with diagonal cutting pliers to the approximate length to fit the nut as shown in figure A. In the interest of safety, hold your hand over the pin while cutting.

_____4. Fully bind the ends of the cotter pin; one against the nut and the other against the end of the bolt, as shown in figure B above.

_____5. After you have installed a cotter pin that resembles the illustrations above, ask your instructor to check your work. If necessary, use a new cotter pin and do the job again.

_____6. When you are satisfied you have properly completed the task, have your instructor inspect your work, and sign below.

Instructor's Signature ________________________________

_____7. Remove the cotter pin from the trainer. Clean up all scrap metal and deposit in FO (foreign object) container.

Have the instructor show you what you are to do for Project III.

PROJECT III

Some electrical connectors used in aircraft are safetied with safety wire. Use .032 steel safety wire and the double twist method to safety the connector as shown below.

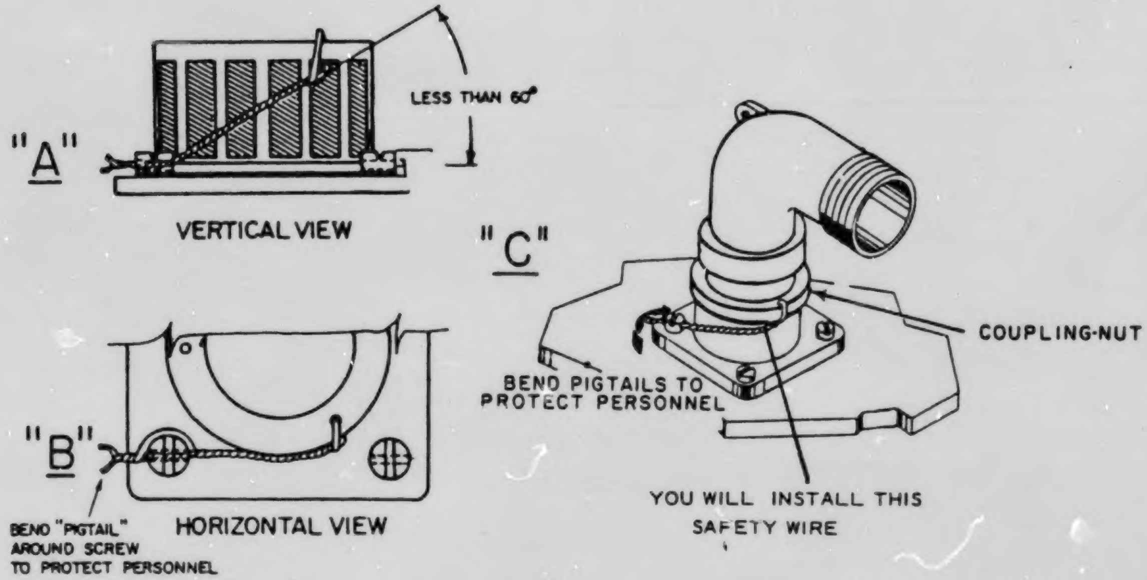

"A"
LESS THAN 60°
VERTICAL VIEW
"B"
BEND "PIGTAIL" AROUND SCREW TO PROTECT PERSONNEL
HORIZONTAL VIEW
"C"
COUPLING-NUT
BEND PIGTAILS TO PROTECT PERSONNEL
YOU WILL INSTALL THIS SAFETY WIRE

Figure 21.

The following procedure will guide you in safetying a connector plug. Place a check (✓) on the blanks as you perform the steps.

_____1. Thread the wire through the hole in the coupling nut.

_____2. Twist the wire by hand in a clockwise direction.

_____3. Continue twisting and pulling the safety wire in the direction of a fillister head screw so that the wire will hold the coupling ring tight.

_____4. Insert the top wire through the fillister head screw so that it pulls this screw in a tightening direction (clockwise).

_____5. Bend the bottom end of the wire around the fillister head screw, and pass it under the other end of the wire. See "B" above.

_____6. With the duckbill pliers, twist the ends of the wire counterclockwise to form a pigtail 1/4 to 1/2 inch long.

_____7. Bend the pigtail counterclockwise around the fillister head screw to eliminate the possibility of snags.

_____8. Have the instructor check your work.

_____9. Remove the wire from the trainer and deposit in FO container.

Have the instructor show you what to do for Project IV.

PROJECT IV

SINGLE WIRE METHOD

One application of the single wire method is shown in the figure below. The single wire method is simpler than the double twist method. It may be used when the screws are arranged in a closed geometrical pattern.

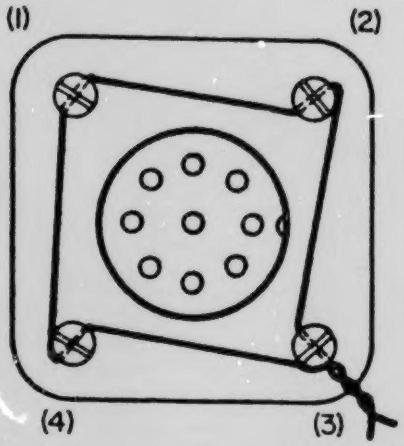


Figure 22. Top View of Connector Plug.

Observe the figure above and safety the base of the connector plug on the trainer using .032 inch diameter carbon steel safety wire by completing the following steps. Check each step as it is completed.

_____1. Thread the wire through the hole in screwhead (1).

_____2. Thread wire through screws in such a manner that if a screw begins to loosen, force will be applied in the tightening direction to another screw (2 or 4).

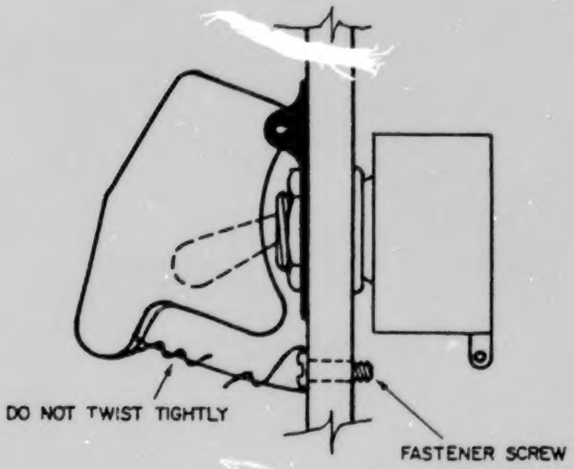
_____3. After threading the wire through screw hole (3), use pliers to twist the wire counterclockwise to form a pigtail 1/4 to 1/2 inch long and secure pigtail (direction of arrow) to protect personnel.

_____4. Have your instructor check your work.

_____5. Remove the safety wire from the trainer and place in FO container.

PROJECT V

SAFETYING EMERGENCY SWITCH COVERS



EMERGENCY DEVICE
SWITCH COVER

Figure 23.

Observing figure 23, safety the emergency device switch cover on the trainer. Use 0.020 inch diameter copper wire. All emergency devices (fire extinguishers, oxygen regulators, emergency jettison of tanks, bombs, etc.) will use this type and size wire. The reason for using 0.020 copper wire is so the pilot can break it when he has a critical need to use the switch.

Note: The pilot will NOT break the safety wire without LOOKING and KNOWING which switch will correct the emergency condition.

Check each step as it is completed.

_____1. Thread one end of the wire through hole in the switch cover, then bring the end around (counterclockwise) to meet the wire. Twist three (3) turns around the wire.

_____2. Thread the other end of the wire through the hole in the fastener screw. Then repeat step 1.

_____3. Cut the excess wire off of each end.

_____4. Have your instructor check your work.

Instructor's Signature: ______________________________

_____5. Remove the safety wire from the trainer and place in FO container. Have your instructor check your table and sign off your criterion check. Return to the reading room and start your next project.

SECTION C

Before you can do any soldering or installing solderless connectors, you must remove the insulation from the end of the electrical wire with a stripping tool. A step by step procedure for stripping, preparing a soldering iron, soldering and installing solderless connectors will follow. Read and follow all instructions carefully. If you have any doubt concerning the instructions, etc., do not hesitate to ask the instructor for clarification.

Report to the instructor and he will sign you out to the lab.

Report to the instructor in the lab area.

To make sure you have each item, place a check in the blank provided as you get each item.

_____1. Stripping tool.

_____2. Crimping tool.

_____3. Soldering iron.

_____4. File.

_____5. File card.

_____6. Diagonal cutter.

_____7. Soldering paste.

The following items should be found on the worktable:

_____1. Electrical connector plug.

_____2. Electrical wires (4 each).

_____3. Solder (1 spool).

_____4. Solderless connectors.

    _____a. Terminal lug (1 each).

    _____b. Splice (1 each).

_____5. Fabric board (1 each).

_____6. Connector plug holder (vice or plug holder).

_____7. Soldering iron holder.

_____8. Wiping cloth or sponge.

_____9. Insulation sleeve (if applicable) (2 each).

____10. Rule (1 each).

PROCEDURE

You should read each exercise through completely before attempting to perform the the task. The instructor will observe and grade you during your performances.

Exercise 1

Procedure for stripping wire with a hand stripper.

Refer to figure 24.

Note: Answer all questions. Correct answers will be listed at the end of this exercise.

a. Take one of the four #20 size copper wires and practice using the stripping tool for removing correct lengths of insulation. Insert wire (step a, figure 24) into exact slot for wire size to be stripped (each slot is marked with wire size).

(1) What slot size(s) should you use?

Answer: ____________________

b. To remove the desired length of insulation (step a) extend the amount of wire to be stripped beyond cutting slot edge. See Note No. 1 and Table 1A and B (page 26).

(1) For "soldering," what should be the length between the top of cup and the wire insulation?

Answer: ____________________

(2) For solderless terminal lugs (#22 - #14) what is the stripping length?

Answer: ____________________

(3) For solderless splices what is the stripping length?

Answer: ____________________

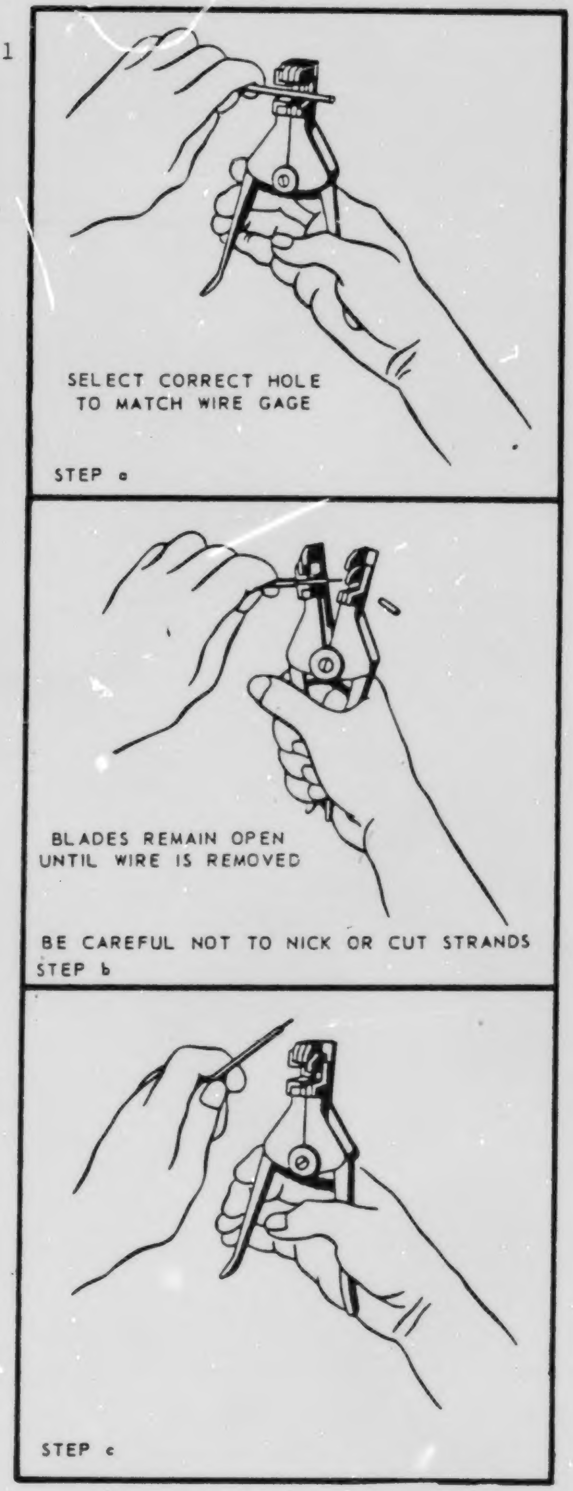
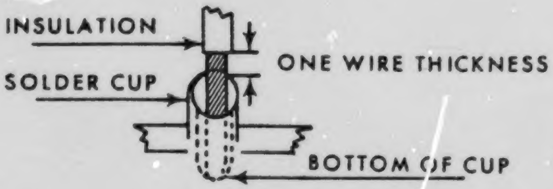

SELECT CORRECT HOLE
TO MATCH WIRE GAGE
STEP a
BLADES REMAIN OPEN
UNTIL WIRE IS REMOVED
BE CAREFUL NOT TO NICK OR CUT STRANDS
STEP b
STEP c

Figure 24.

Note No. 1

The stripped portion of the wire should be such that when it bottoms in the solder cut there will be a gap of approximately one wire thickness between the top of the cup and the insulation.

Example:



c. Now, after determining the length of insulation to remove. close handles together (step b, figure 24) as far as they will go to remove insulation.

d. Release handles, allowing wire holder to return to open position (step c, figure 24).

e. Remove stripped wire (step c, figure 24) from stripper and examine wire for nicked or broken strands. See table 2.

(1) For the wire size you are using, how many nicked or broken strands are allowed?

Answer: ____________________

(2) For aluminum wire, how many strands can be nicked or broken?

Answer: ____________________

(3) If above tolerance is not met, cut the wire end and strip again.

A

Wire Stripping Lengths for Small Copper Terminal Lugs

Wire Size	Stripping Length (in inches)
#26 & #24	5/32
#22 & #20	3/16
#18 - #14	1/4
#12 & #10	9/32

B

Stripping Length for Small Copper Splices

Wire Size	Stripping Length (inches)
26 - 24	5/32
22 - 14	7/32
12 - 10	5/16

Table 1. Stripping Length for Solderless Connectors.

Wire	Nicked or Broken Strands
Copper	
AN #22 - #12	None
#10	2
#8 - #4	4
#2 - #0	12
Aluminum, all sizes	None

Table 2. Allowable Nicked or Broken Strands.

Note:

1. Longitudinal scratches in copper wire are not considered cause for rejection or rework.

2. Make sure insulation is clean-cut with no frayed or ragged edges. Trim, if necessary.

3. Make sure all insulation is removed from stripped area. Some types of wires are supplied with a clear transparent layer between conductor and primary insulation. If this is present, remove it.

4. Retwist strands by hand, if necessary, to restore natural lay and tightness of strands.

f. Now the instructor will grade you as you take the three remaining wires and accomplish the following by stripping:

(1) One end of each of the three wires for "soldering." Strip to 9/32".

(2) The opposite end of ONE wire for a "terminal lug." Strip to 3/16".

(3) The opposite end of the OTHER two wires for a "splice." Strip to 7/32".

Answers to Exercise 1: a(1) 18 - 20 b(1) 1/32" b(2) 3/16"

b(3) 7/32" e(1) None e(2) None

Exercise 2

Preparing the Soldering Iron

Before using the soldering iron, if the iron's tip is a dull, scaley-brown color, it should be prepared as follows:

a. With the iron shut off, file each working surface of the iron's tip with a file until it is smooth and of a bright copper color (CHECK WITH INSTRUCTOR BEFORE ACCOMPLISHING THIS STEP). Remove copper fuzz from dressed edges with a file card. See figure 25

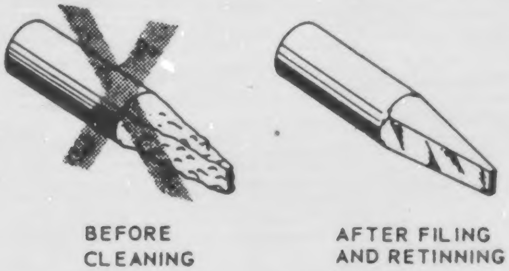
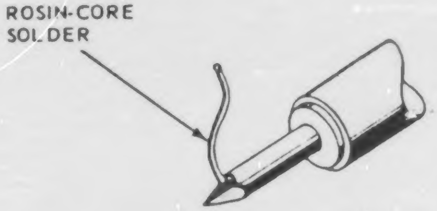


Figure 25.

Note: Soldering iron tips coated with pure iron are not to be filed. If the tip is brown in color and pitted, replace it.

b. Plug in the iron and apply core (rosin) solder just as the bright dressed copper color is turning to pigeon-blue, bronze oxide color. This will allow the flux to "wet" and clean the working area of the tip. The solder will melt and form an even bright silver coating on the tip. This process is called "tinning." See figure 25.



NOTE: TIN WHILE IRON IS HEATING

Figure 26.

Caution: Do not allow iron to come up to full temperature before starting the tinning operation.

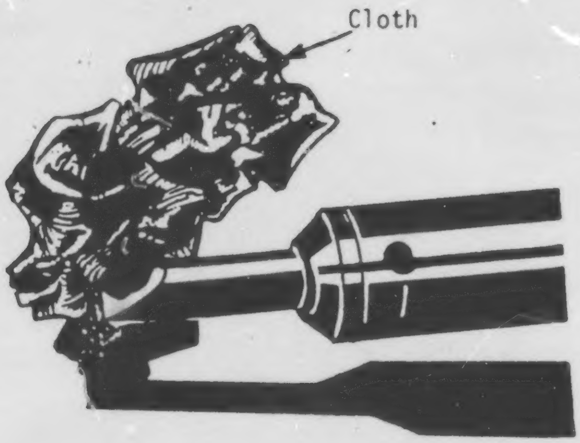


Figure 27.

c. Wipe off excess solder with a damp sponge or a cloth. See figure 27.

Caution: Never shake or "whip" an iron to get rid of dross (scum that forms on molten metal) or excess solder droplets.

Exercise 3

Solder Wires Into Electrical Connector

With the clean tinned soldering iron proceed as follows:

a. Apply solder paste and tin the three wire ends you previously stripped to 9/32". Hold the wire to the flat portion of the soldering iron tip and apply a small amount of solder to the wire. See figure 28. The instructor will demonstrate, if necessary.

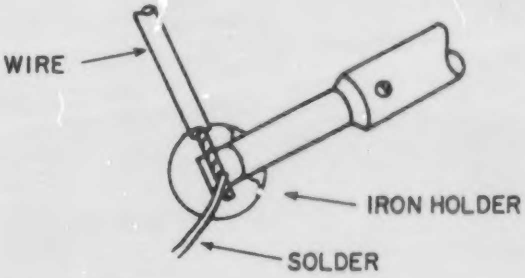


Figure 28. Tinning Wire.

Note: Before each application, wipe the soldering iron tip with a damp sponge or cloth. This will remove surface dross and excess solder from the tip.

b. Tin the three cups as shown in figure 29. Place the soldering iron tip against the bottom of the cup and apply solder at the exact point on the cup opposite the iron. DO NOT OVERFILL CUPS.

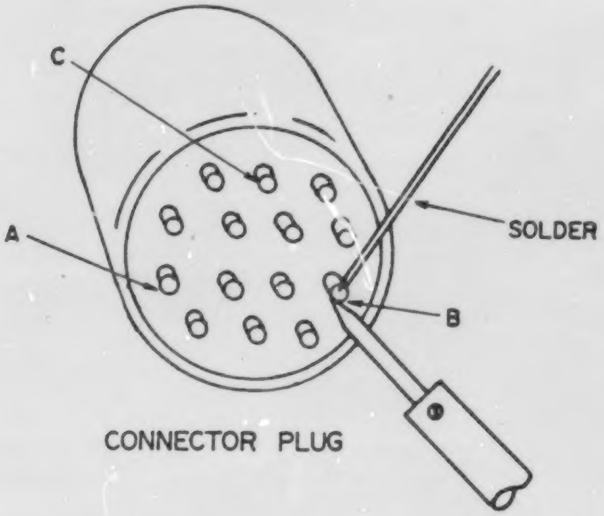


Figure 29. Tinning Solder Cup.

Note: During the soldering exercise do not let the iron overheat. If the iron overheats, the tip should be retinned.

c. Solder the pre-tinned wires into the electrical connector plug in the following sequence:

(1) Heat the pre-tinned cup "A" until the solder is melted. Insert the 9/32" end of the pre-tinned wire in cup "A." Remove the soldering iron tip from the cup while holding the wire firmly in place.

(2) Heat the pre-tinned cup "B" until the solder is melted. Insert the 9/32" end of the pre-tinned wire in cup "B." Remove the soldering iron tip from the cup while holding the wire firmly in place.

THE ABOVE TWO WIRES WILL BE SPLICED TOGETHER IN EXERCISE 4, STEP 2

(3) Heat the pre-tinned cup "C" until the solder is melted. Insert the 9/32" end of the pre-tinned wire in cup "C." Remove the soldering iron tip from the cup while holding the wire firmly in place.

THIS WIRE WILL BE USED TO APPLY A TERMINAL LUG IN EXERCISE 4 STEP 1

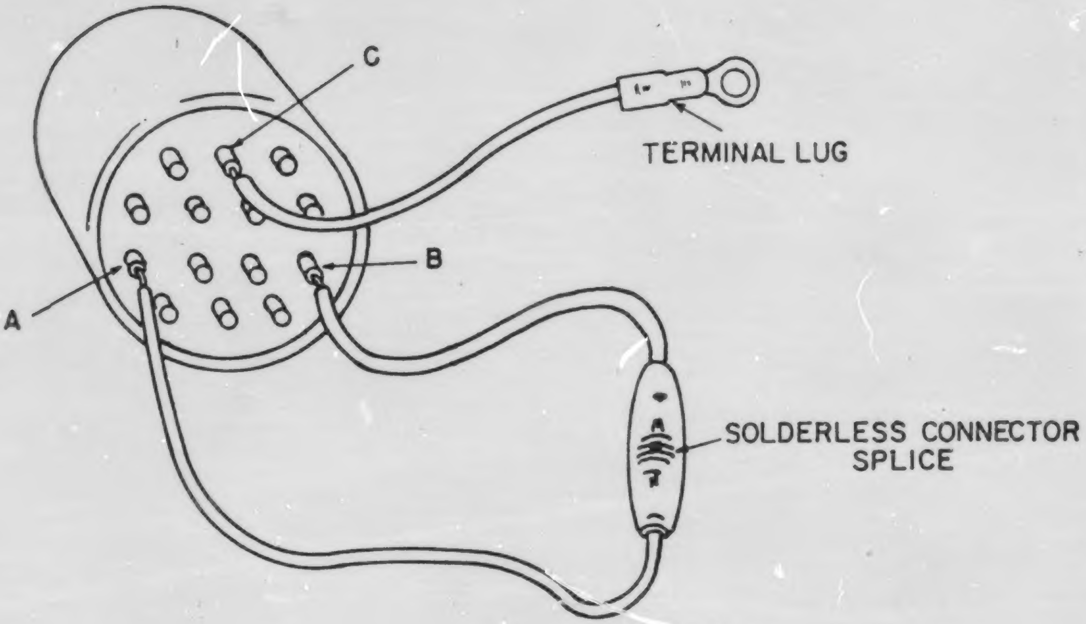

C
TERMINAL LUG
B
A
SOLDERLESS CONNECTOR SPLICE

Figure 30.

Note: Do not hold iron against cup any longer than is required to melt the solder in the cup and on the wire.

d. Now, inspect the soldered joints for excessive solder or flux, burned insulation, solder covering entire length of exposed wires, and cold solder joints, figure 31. Other than excessive solder or flux, a resoldering job is required.

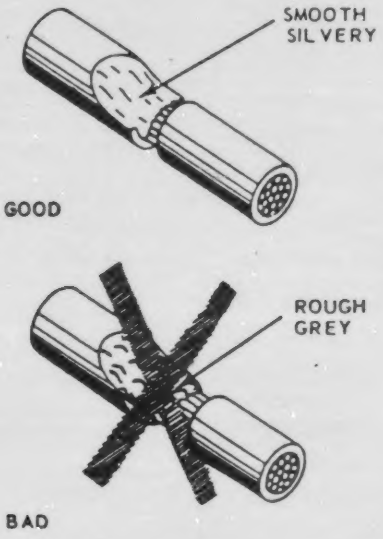

SMOOTH SILVERY
GOOD
ROUGH GREY
BAD

Figure 31.

392

If you had many wires to solder into a connector plug, a soldering sequence should be used (figure 32).

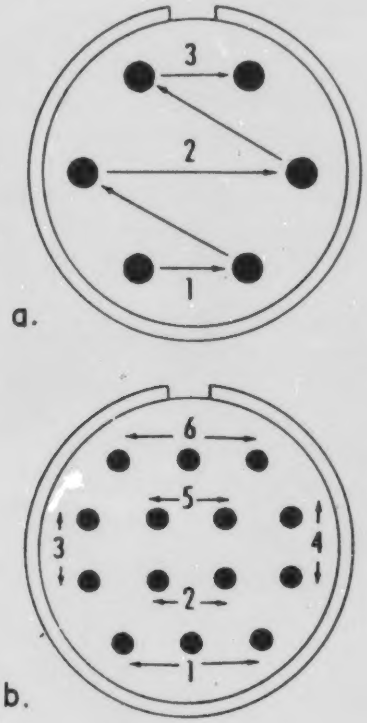


Figure 32.

Exercise 4

Installing Solderless Connectors

1. You are going to install solderless connectors on the ends of the three wires you just soldered into the electrical connector. The first installation will be the terminal lug, so proceed as follows:

a. Insert the terminal lug tongue first into the jaws of the crimping tool. Insure that the terminal lug barrel butts flush against the locator. See figure 32 for correct insertion.

(1) For the size wire you are using, what nest should you use?

Answer: ____________________

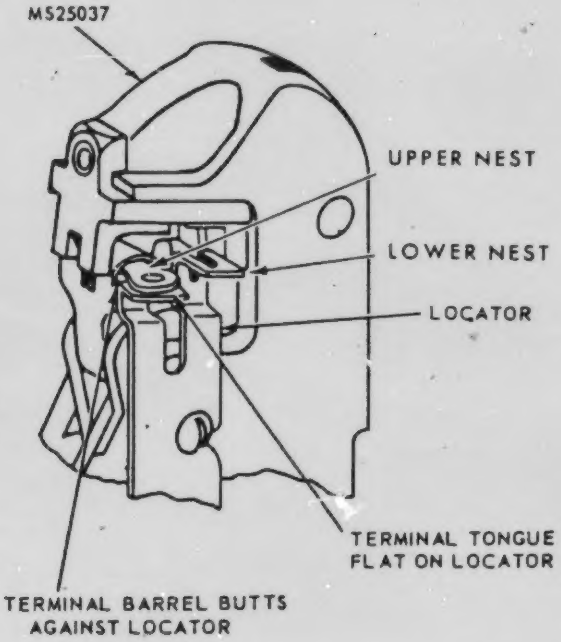

MS25037
UPPER NEST
LOWER NEST
LOCATOR
TERMINAL TONGUE FLAT ON LOCATOR
TERMINAL BARREL BUTTS AGAINST LOCATOR

Figure 32. Insertion of Terminal Lug Into Crimping Tool.

b. Squeeze the crimping tool handles slowly until the tool jaws hold the terminal lug barrel frimly in place, but without denting it. Release the handles.

(1) When the handles were released, was the terminal lug still held firmly?

Answer: ____________________

c. Insert the exposed wire end that was stripped for "terminal lug" into the terminal lug barrel until the wire insulation butts flush against the end of the barrel.

d. Squeeze the tool handles until the ratchet releases.

e. Remove the completed assembly from the crimping tool and examine visually for the following:

(1) Indent centered on the terminal lug barrel.

(2) Terminal lug barrel for cracks.

(3) Terminal lug insulation for cracks.

(4) Insulation grip for crimp.

Note: The instructor will inspect the terminal lugs for the above defects. If any defects are found, the terminal lug should be cut off and another one installed.

2. For installing solderless splices, refer to figure 10 and proceed as follows:

a. Swing the locator (stop plate) used for installing terminal lugs out of the way. See figure 33a.

b. Position the splice in the correct die nest as indicated by the "Instruction Plate" for the size wire you are using (exercise 1, para a) so that side of splice to be crimped is on the conical die side (figure 33b and c) of the locator groove.

c. Squeeze the crimping tool handles until the dies hold the splice firmly in place, but without denting it.

d. Insert wire into the "wire in" side of splice (figure 33d) so that the stripped wire butts against the stop in the center of the splice. This can be seen through the splice inspection window (figure 33c).

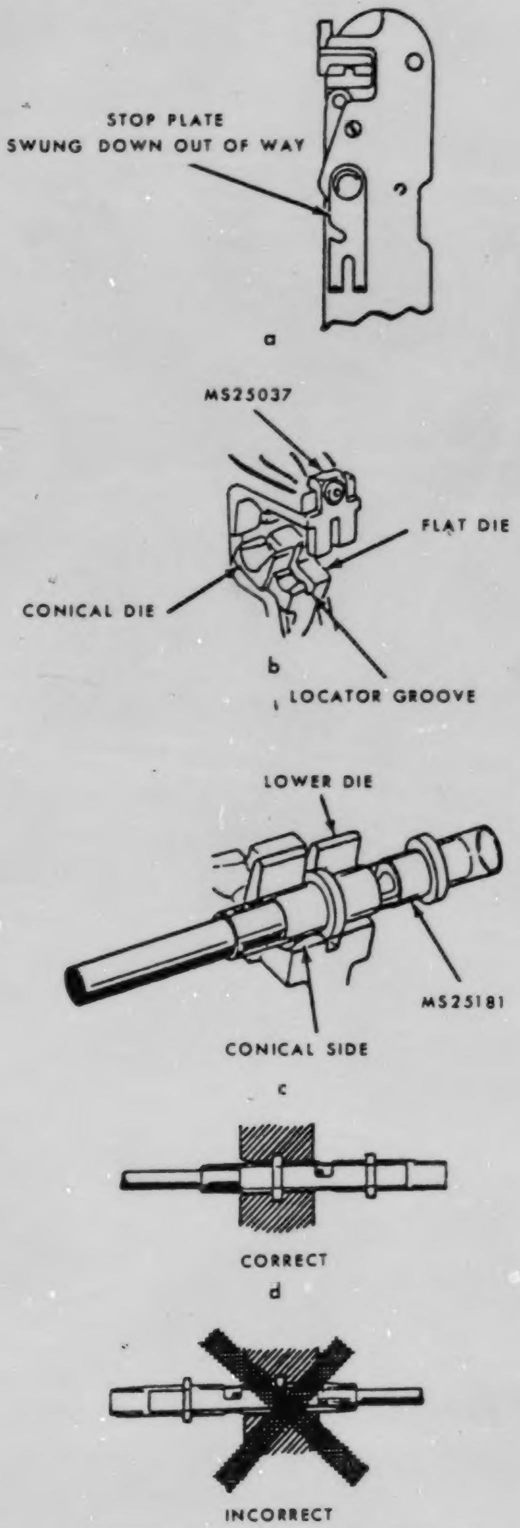

STOP PLATE
SWUNG DOWN OUT OF WAY
a
MS25037
FLAT DIE
CONICAL DIE
b
LOCATOR GROOVE
LOWER DIE
MS25181
CONICAL SIDE
c
CORRECT
d
INCORRECT

Figure 33. Locating Splice in Crimping Tool.

e. Crimp by closing the tool handles: the tool will not open until full crimping pressure has been applied.

f. After crimping, check that the wire end is still visible through the inspection window and visually examine the splice for the indications outlined in exercise 4, step 1e, items 1 through 4.

THE INSTRUCTOR WILL INSPECT THE SPLICE.

Now, desolder the three wires in the electrical connector plug, clean the solder and flux from the cups (the instructor will demonstrate). Clean the general area and return the tools to the kit or the shadow board. The instructor will inspect the area before you leave.

Answers to Exercise 4: 1a(1) Upper nest
1b(1) Yes (if "No" defective tool)

Note: To prolong the life of the soldering iron tip, remove the tip from the iron once a day and clean the black scale from the tip and the inside of the iron with fine steel wool.

PROGRAMMED TEXT
3ABR32632B-PT-204C
3ABR32530-1-PT-105C
3ABR32531-PT-105C

Technical Training

Integrated Avionics Systems Spcialist
Automatic Flight Control Systems pecialist
Avionics Instrument Systems Specialist

MAINTENANCE FUNDAMENTALS
SPECIAL HANDTOOLS, SAFETYING DEVICES, SOLDERING AND SOLDERLESS CONNECTORS

20 March 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR32632B, 3ABR32530-1, and 3ABR32531 courses. It was validated using 30 students from the respective courses. Average time to complete this text is 120 minutes.

OBJECTIVES

1. Without reference, identify facts concerning Maintenance Fundamentals. An accuracy of 70% is required.

   a. Special handtools.

   b. Safetying devices.

   c. Soldering techniques and solderless connectors.

INSTRUCTIONS

SECTION A: This section covers facts you should know about torque wrenches.

SECTION B: This section covers facts you should know about safetying hardware.

SECTION C: This section covers facts you should know about soldering and solderless connectors.

Note: You will be tested on your knowledge of the material in this PT before being allowed to perform in the lab. You will be required to obtain a minimum of 70% on the written appraisal.

Each section allows you to proceed step-by-step through the material. Each step (frame) teaches you a small amount of material and you are asked to respond to that information. Read the information carefully and respond as directed. Check your responses with the correct answers listed at the bottom of the following page. Do not proceed until you have responded correctly. If you need assistance, check with your instructor. Read carefully, but DO NOT HURRY.

Note: Place all responses on the answer sheet. DO NOT MARK in this programmed text.

Supersedes 3ABR32531-PT-110, 3ABR32632B-PT-211A, 30 October 1974; 3ABR32530-1-PT-105E, 3ABR32531-PT-105E, 3ABR32632B-PT-204E, 23 March 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 200; TTVSA - 1

SECTION A

SPECIAL TOOLS

Frame 1

There are many different types of special tools used in the Air Force today. One such special tool is the torque wrench.

The torque wrench is used to tighten common hardware, such as nuts and bolts, to specific torque values. Using specific values prevents under-tightening (leaving loose) or overtightening (stressing or twisting off), the nuts or bolts.

NO RESPONSE REQUIRED

Frame 2

Torque wrenches are used to measure torque (twisting force) applied to bolts and nuts when they are being installed. Some wrenches are designed to measure torque in inch-pounds, others in foot-pounds. Regardless of which torque wrench you have, the procedure for setting and using the torque wrench will remain the same. The most common type of torque wrench used in the Air Force is the "breakaway" type, sometimes referred to as the automatic-release-torque wrench. This is the only type of torque wrench authorized for use on common aircraft hardware (nuts, bolts, etc). The breakaway torque wrench (see illustration below) has a square socket drive, shaft scale, vernier scale, handle grip, and a grip lock.

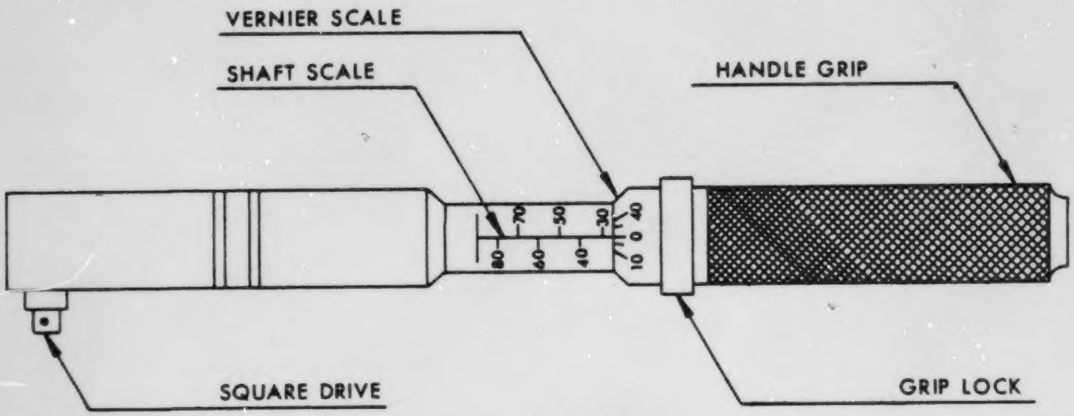


Figure 1.

Make a check (✓) by the correct statement(s).

_____a. Torque wrenches measure torque in foot-pounds only.

_____b. The "breakaway" type torque wrench is the most commonly used toruqe wrench in the Air Force.

_____c. The breakaway torque wrench has a vernier scale and grip lock on the handle grip.

_____d. Common aircraft hardware should NOT be torqued with a "breakaway" type torque wrench.

Frame 3

Other types of torque wrenches such as the screwdriver type, the flexible beam type and the dial type are not authorized for tightening common aircraft hardware. However, in specific applications of checking torque, an aircraft technical manual (technical order) or an equipment maintenance manual (TO) may require one of the above mentioned wrenches to be used.

Note: The term "torque wrench" in portions of this text is shortened to "wrench."

Make a check (✓) by the correct statement(s).

_____a. Any type of torque wrench is authorized for use on common aircraft hardware.

_____b. The flexible beam type torque wrench should NOT be used to torque a nut on an aircraft.

_____c. An aircraft technical manual will never list a type of torque wrench other than the authorized "breakaway" type.

_____d. An equipment maintenance manual (technical order) may require that a dial type torque wrench be used.

Answers to Frame 2: _____a. __✓__b. __✓__c. _____d.

Frame 4

The breakaway torque wrenches are adjustable. A desired torque value can be set (within limits of the torque wrench) by turning the handle grip to settings on the micrometer type scale. A micrometer type scale is a spindle moved by a finely threaded screw for making precise measurements. Referring to the illustration below notice that the shaft scale is graduated in increments of 50. The micrometer type vernier scale is graduated from 0 to 50 in increments of 5. One complete turn of the vernier scale will increase or decrease the setting by 50 inch-pounds or 50 foot-pounds depending on the wrench you have.

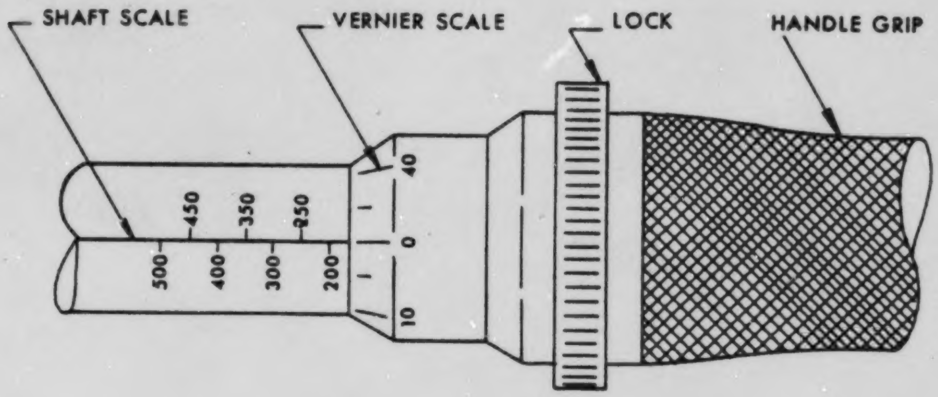


Figure 2.

Make a check (✓) by the correct statement(s).

_____a. Breakaway torque wrenches are not adjustable.

_____b. The micrometer (the shaft scale and the vernier scale) is used to indicate the amount of torque set on the wrench.

_____c. The shaft scale is graduated in increments of 50.

_____d. One complete turn of the handle will increase or decrease the torque value by 50.

Answers to Frame 3: _____a. ✓ b. _____c. ✓ d.

Frame 5

To increase the torque setting of the wrench, turn the handle grip clockwise. To reduce the torque setting, turn the handle grip counterclockwise. Turning the handle grip lengthens or shortens the handle; it also changes the scale reading of the micrometer type scale, while at the same time reducing or increasing tension on the spring inside the handle. The desired torque setting ahould always be approached from the lower end of the micrometer type scale. This means you will first lower the torque setting to less than you wish to set in, then increase to the desired setting.

Make a check (✓) by the correct statement(s).

_____a. To change the torque value on the wrench, the handle grip must be turned.

_____b. A torque setting is always approached from the lower end of the scale.

_____c. To increase the torque setting, the handle is turned counterclockwise.

_____d. Turning the handle reduces or increases tension on the spring inside the handle.

Answers to Frame 4: _____a. __✓__b. __✓__c. __✓__d.

Frame 6

The breakaway torque wrench has a locking device to insure that the desired torque value does not change when the wrench is being used. On some wrenches, the lock ring is turned (figure A) to lock or unlock the handle. On other wrenches, locking or unlocking is accomplished by sliding the lock ring along the handle to release or engage a pawl or slot in the shaft (figure B). In either case, the grip is prevented from turning when the wrench is in use. The lock must be "unlocked" before the handle grip can be turned to change the torque setting. In either case the handle can only be "locked" when a number on the vernier scale (0, 5, 10, etc) is in line with the "Shaft Index Line" (see illustration below).

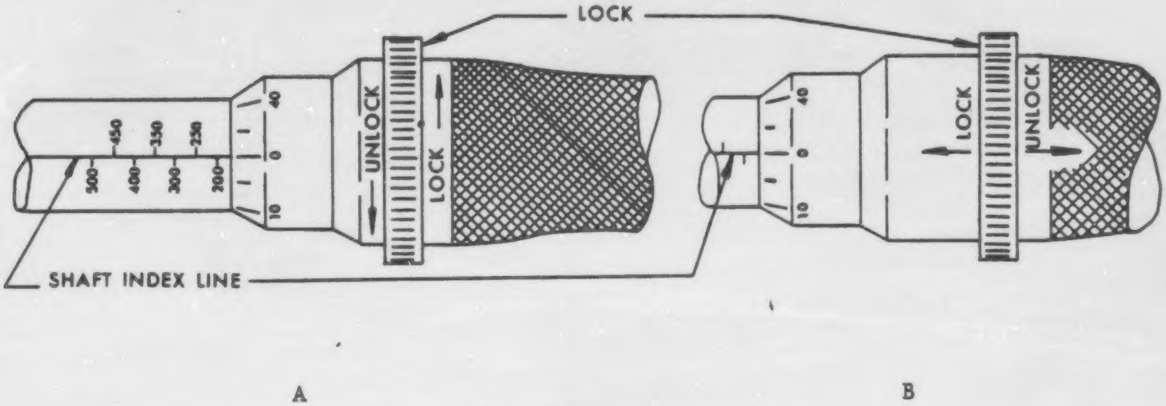


Figure 3.

Make a check (✓) by the correct statement(s).

_____a. The breakaway torque wrench has a locking device.

_____b. The handle grip cannot be turned when the lock is "unlocked."

_____c. A number on the Vernier scale must be in line with the "Shaft Index Line" before the locking device will "lock."

Answers to Frame 5: __✓__ a. __✓__ b. _____ c. __✓__ d.

Frame 7

The torque wrench will automatically release or "click" when the desired amount of torque has been applied to a nut or bolt. When the handle releases, it will have approximately 15° to 20° of free travel or movement before catching again. The handle should not be pulled after it has released. You should use a slow, steady pull on the wrench to prevent passing the release without recognizing it. This click or release is known as "breakaway."

Make a check (✓) by the correct statement(s).

_____a. The handle should be pulled after it releases or "breaks."

_____b. When the handle releases or "breaks" the desired amount of torque has been applied.

_____c. The handle should not be pulled beyond the 15° or 20° of free travel.

Answers to Frame 6: __✓__a. _____b. __✓__c. A25

Identify the parts of the torque wrench on the illustration below by selecting the names from the list and writing the names in the appropriate numbered spaces on the illustration.

NAMES

Grip Lock	Handle Grip	Vernier Scale
Shaft Scale	Socket Drive	

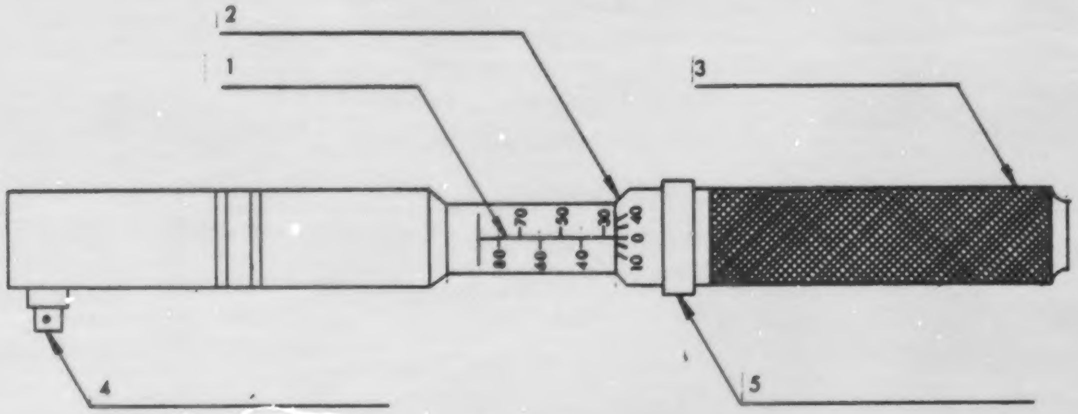


Figure 4.

Answers to Frame 7: ____a. __✓__b. __✓__c.

Frame 9

From time to time during torque applications, it may be necessary to convert from inch-pound specifications to a setting for a foot-pound torque wrench. To convert inch-pounds to foot-pounds divide the figure to be converted by 12 (number of inches in one foot). For example, 600 inch-pounds divided by 12 equals 50 foot-pounds. If the technical order called for 600 inch-pounds and you had a foot-pound torque wrench you would set the wrench at 50 foot-pounds. To convert foot-pounds to inch-pounds, you would multiply the figure to be converted by 12 (number of inches in one foot). Example: 10 foot-pounds multiplied by 12 equals 120 inch-pounds to set on the inch-pound torque wrench.

Make a check (✓) by the correct statement(s).

_____a. To convert inch-pounds to foot-pounds divide the foot-pounds by 12.

_____b. To convert foot-pounds to inch-pounds multiply the foot-pounds by 12.

_____c. Twelve (12) foot-pounds is equal to one (1) inch-pound.

_____d. Forty-eight (48) inch-pounds are equal to four (4) foot-pounds.

Answers to Frame 8:
1. Shaft Scale
2. Vernier Scale
3. Handle Grip
4. Socket Drive
5. Grip Lock

Frame 10

Torque wrenches issued from supply to the shops or tool cribs for use in the maintenance of aircraft and other critical equipment will be verified (checked for accuracy) at least once every two months (60 days). Verification means sending the wrench to the shop that has the torque wrench tester. They will set the wrench at different settings and pull it to determine that it will break or release at the proper torque. The 60 calendar day period is to be calculated from the date of the verification. For example, a wrench verified on 15 January 1977 will be due reverofocatopm on 15 March 1977. At the time of verification, a color code tape stamped with the due date is fastened to the torque wrench (see illustration below).

NOTE: VERIFICATION - a checking operation, using a suitable torque wrench tester to determine serviceability for use or requiring calibration. The time required to verify is approximately 10 minutes.

CALIBRATION - The act of actually making adjustments to bring a torque wrench into acceptable tolerances as specified by the technical order. Time required to calibrate varies from 1 hour to 8 hours for some wrenches.

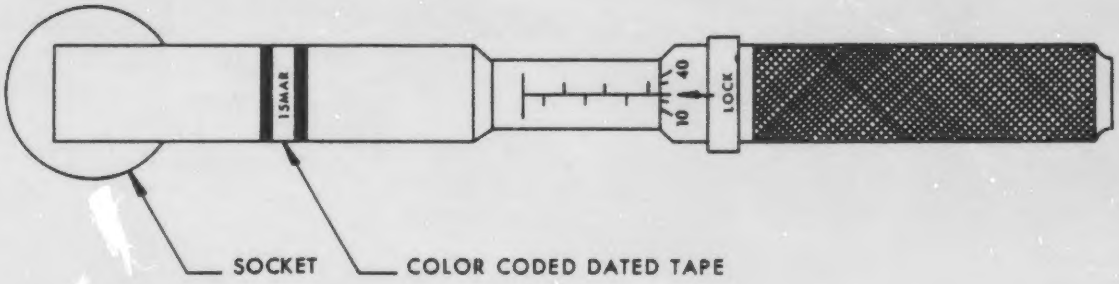


Figure 5.

Make a check (✓) by the correct statement(s).

_____a. Torque wrenches in the shops or tool cribs shall be verified at least once every two months (60 days).

_____b. A color coded tape is fastened to the torque wrench during verification.

_____c. A torque wrench will always be calibrated before it is verified.

_____d. Calibration is the actual adjustment of the wrench to operate within specified tolerances.

Answers to Frame 9: ✓ a. ✓ b. _____c. ✓ d.

Frame 11

The following colors of color code tapes are used to indicate the month the torque wrench is due verification.

Colors	Months
Blue	January - May - September
Red	February - June - October
Black	March - July - November
Yellow	April - August - December

Note: If a torque wrench is dropped or otherwise abused, it will be VERIFIED, (checked for accuracy) before re-use. If it is found to be out of tolerance, it will be calibrated before being returned.

Make a check (✓) by the correct statement(s).

_____a. The color of the color code tape will indicate the day, month, and year the torque wrench was verified.

_____b. By looking at the date and color of the color code tape, one can determine when the torque wrench was verified.

_____c. Each color of the color code tape represents three different months.

Answers to Frame 10: __✓__a. __✓__b. _____c. __✓__d.

Frame 12

Torque wrenches are precision measuring instruments and should be handled and treated like precision instruments. After using these wrenches, you should turn the grip counterclockwise to its lowest indicated setting. This removes the tension on the spring in the handle. See note. The lowest indicated setting is the lowest number on the shaft scale and zero on the vernier scale. The accuracy of the spring tension determines the accuracy of the wrench. The wrench should be stored in its own storage container with the wrench at its lowest indicated setting.

Make a check (✓) by the correct statement(s).

_____a. Torque wrenches are precision measuring instruments.

_____b. Torque wrenches are stored at their highest setting.

_____c. Torque wrenches are stored in toolboxes.

_____d. Torque wrenches are stored at their lowest setting in their own storage containers.

Note: Do not force the handle grip fully CCW. A mechanical stop could be displaced and the torque wrench's accuracy affected. Calibration would be required before re-use.

Answers to Frame 11: _____a. __✓__b. __✓__c.

409

Frame 13

The following are a few precautions to observe concerning torque wrenches:

1. Do not use an extension on the grip end of the handle.

2. Do not use a torque wrench to loosen previously tightened nuts or bolts.

3. Do not apply a greater amount of torque than the rated capacity of the wrench.

4. Do not attempt to change the setting without first unlocking the handle.

5. Do not place an extension on the square drive that increases the length of the torque wrench without mathematically calculating the torque value to set on the handle.

NO RESPONSE REQUIRED

Answers to Frame 12: __✓__a. _____b. _____c. __✓__d.

PART B

SAFETYING DEVICES

Frame 14

Once you have used a torque wrench to tighten the nuts or bolts to the specified values, a method must be used to keep them from vibrating loose during operation and causing failure. The AF uses many different methods. You have already covered self-locking nuts and use of lock washers. This section will cover the use of safety wire and cotter pins as a method of preventing hardware from vibrating loose.

NO RESPONSE REQUIRED

Answers to Frame 13: No Response Required

411

Frame 15

Some vibration is present in all aircraft during flight. Therefore, if bolts, screws, or other components are not properly secured, they could vibrate loose and cause system failure or accidents. To reduce the possibilities of system failures caused by components coming loose, several safetying methods are used. Safety wire and cotter pins are used to secure such items as bolts, screws, nuts, snap rings, connector plugs, etc.

Make a check (✓) by the correct statement(s).

What is the purpose of safetying hardware or components?

_____a. To keep the pilots from removing hardware or components in flight.

_____b. To keep hardware from loosening up on the ground.

_____c. To reduce the possibility of loose components causing failures.

_____d. To reduce vibration in hardware and components.

Answers to Frame 14: No Response required

433

SINGLE WIRE METHOD

One method of safetying is to use a single wire. It is used to safety closely spaced screws in a closed geometrical pattern. See the figure below. The safety wire is installed so that the fillister head screws cannot loosen. The number of screws that can be wired together depends on the application. Remember they must be arranged in a closed geometric pattern.

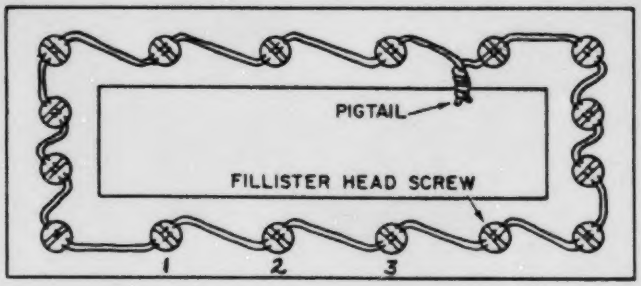


Figure 6.

Make a check (✓) by the correct statement(s).

1. Screw number 2 cannot loosen because it will

_____a. stretch the safety wire between all other screws.

_____b. loosen screws numberd 1 and 3.

_____c. stretch the safety wire between screws 1 and 3.

_____d. overtorque screws numbered 1 and 3.

2. The method used to wire together screws in a closed geometrical pattern is referred to as the

_____a. single-wire method.

_____b. double-wire method.

_____c. single-twist method.

_____d. double-twist method.

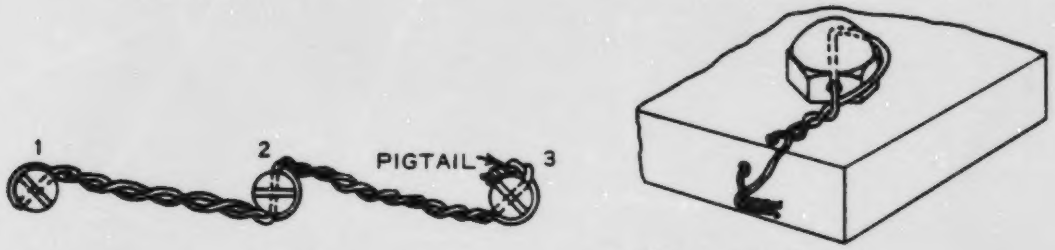
Answers to Frame 15: _____a. _____b. __✓__c. _____d.

Frame 17

DOUBLE TWIST METHOD

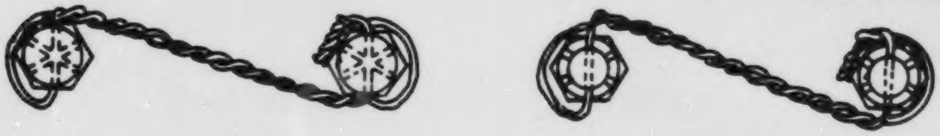
The most common method of safetying used is the double-twist method. This method can be used to safety bolts, nuts, and screws that are either closely spaced or widely spaced. The figures below illustrates the double-twist method for safetying bolts and screws with right-hand threads. When securing widely spaced bolts, 4 to 6 inches apart, the maximum number that can be wired in series is three. When securing closely spaced bolts, the number that can be secured by a 24-inch length of wire is the maximum number that can be wired in series. On bolts that are more than 6 inches apart the double twist single fastener application is used.

Note: In all applications the end or pigtail is tucked against something (nut, bolt, etc.) to prevent snagging or cutting your fingers (safety).



SCREW HEADS DOUBLE-TWIST METHOD

DOUBLE TWIST
SINGLE FASTENER APPLICATION
(MORE THAN 6 INCHES FROM ANOTHER BOLT)



BOLT HEADS

CASTLE NUTS

Figure 7.

Make a check (✓) by the correct statement(s).

1. Screw number 1 cannot loosen because it would

_____a. have to tighten screw number 2.
_____b. have to stretch the safety wire between screw numbers 1 and 2.
_____c. loosen screw number 3.
_____d. tighten the wire between screw numbers 2 and 3.

2. Widely spaced bolts are

_____a. 2 to 3 inches apart.
_____b. secured by the single fastener application if they are more than 6 inches apart.
_____c. never secured with more than three in series.
_____d. not limited to a definite number that can be secured with a 24-inch length of wire.

Answers to Frame 16: 1. _____a. _____b. __✓__c. _____d.
2. __✓__a. _____b. _____c. _____d.

Frame 18

In your lab project you are going to safety three bolts on the trainer, as shown in the illustration below. You will use steel safety wire size 0.032 inch diameter. When working on aircraft systems, the size and type of safety wire to use will be specified in the aircraft's technical order. Example: 1B-52G-2-11, Instruments TO - "Use new corrosion-resistance steel safety-wire 0.032 inch diameter to safety connectors. Using either the single wire or double twist method, 0.032 corrosion-resistance steel safety wire will usually be specified."

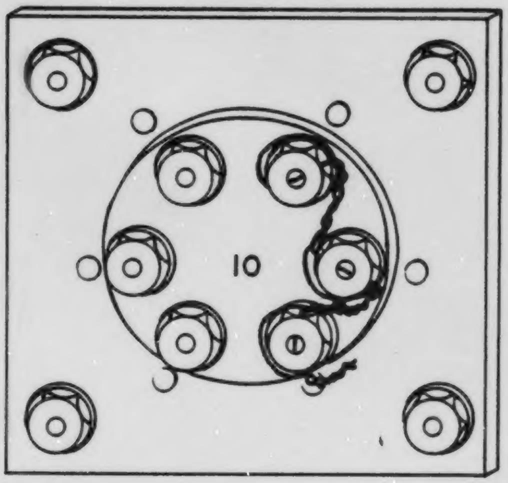


Figure 8.

Make a check (√) by the correct statement(s).

The bolts safetied in the illustration above

_____a. are safetied with the single-wire method.
_____b. are safetied so that loosening any bolt will tighten the wire.
_____c. have left-hand threads.
_____d. are tightened by turning them counterclockwise.
_____e. should be safetied with the size safety wire specified in the aircraft TO.

Answers to Frame 17:
1. __√__a. __√__b. _____c. _____d.
2. _____a. __√__b. __√__c. _____d.

Frame 19

COTTER KEYS (PIN)

Some nuts cannot be safetied with wire because the bolts are free to turn, or because there is only one nut. Cotter keys (pins) are used to safety these nuts as shown in the illustration below. Note that the cotter key (pin) fits through the nut and bolt, locking the two together. Also notice that one end of the cotter key is bent flat against the end of the bolt and ends approximately half way across the end of the bolt. The other end extends approximately half way down the side of the nut and is bent tight against the nut.

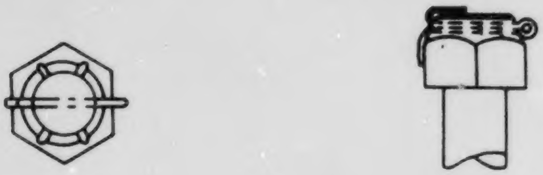


Figure 9.

Make a check (✓) by the correct statement(s).

What method is used to safety nuts when the bolts are free to turn or there is only one bolt?

_____a. Single wire.

_____b. Double twist.

_____c. Cotter key.

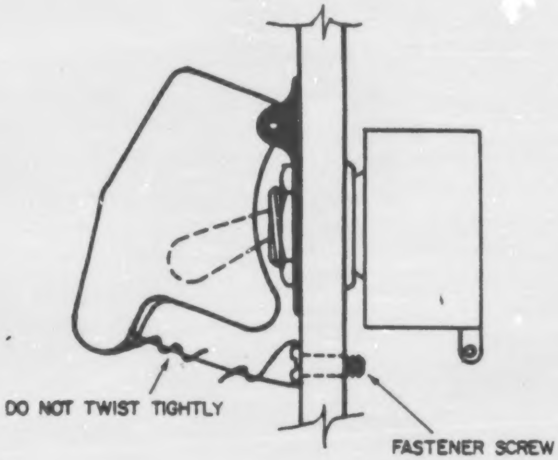
_____d. Single twist.

Answers to Frame 18: _____a. __✓__b. _____c. _____d. __✓__e.

Frame 20

EMERGENCY SWITCH COVERS (GUARDS)

Some emergency switches, such as emergency jettison of external tanks, bombs, etc., or emergency landing gear switch, have a guard covering the switch to prevent accidentally actuating them. To further prevent accidentally turning the switch on, the guard is safety wired closed using .020 copper safety wire. The reason for using .020 copper wire is so the pilot can break it when he has a need to use the switch. The single wire method is used to safety them. NOTE: The pilot will NOT break the safety wire without LOOKING and KNOWING that he has the correct switch.



EMERGENCY DEVICE
SWITCH COVER

Figure 10.

Make a check (✓) by the correct statement(s).

_____1. Emergency switch guards are safety wired using .020 copper safety wire.

_____2. Emergency switch guards are safetied using the single wire method.

Answers to Frame 19: _____a. _____b. __✓__c. _____d.

417

Frame 21

Make a check (✓) by the correct statement(s).

1. What is the purpose of safetying hardware and components?

_____a. To keep hardware from loosening up on the ground.

_____b. To reduce vibrations in hardware and components.

_____c. To reduce the possibilities of failure caused by loose components.

_____d. To keep components from being removed in flight.

2. What method would be used to safety emergency switch guards and closely spaced screws in a closed geometrical pattern?

_____a. Single wire.

_____b. Double twist.

_____c. Cotter key.

_____d. Single fastener.

3. What is the most common safetying method used for both closely or widely spaced hardware?

_____a. Single wire.

_____b. Double twist.

_____c. Cotter key.

_____d. Single fastener.

4. What is the safetying method used to safety nuts when the bolts are free to turn?

_____a. Single wire.

_____b. Double twist.

_____c. Cotter key.

_____d. Single fastener.

439

Answers to Frame 20: __✓__1. __✓__2.

PART C

SOLDERING AND SOLDERLESS CONNECTORS

Frame 22

Another portion of Maintenance Fundamentals that goes along with emoving and installing components, torquing and safetying is the repair of the wires to the components. You may be required to solder a new wire into a circuit, or splice a wire to repair it or install a terminal on it. This section will discuss both use of a soldering iron to solder wires and the use of the flat crimp tool for installation of insulated terminals and insulated splices.

No Response Required

Answers to Frame 21:
1. ____a. ____b. __✓__c. ____d.
2. __✓__a. ____b. ____c. ____d.
3. ____a. __✓__b. ____c. ____d.
4. ____a. ____b. __✓__c. ____d.

Frame 23

Soldering is a method of bonding two pieces of metal together by the use of an alloy (solder) with a comparatively low melting point. Solder must always melt at a lower temperature than the base metals. Soldering should not be confused with welding, for in the welding process the two metals to be joined are actually fused together. In the soldering process, the base metals are not fused, but are merely coated (tinned) with the solder alloy and then sweated together or joined by the application of heat. Soldered joints should not be relied upon for extra strength. However good they may be, they must not be subjected to excessive vibrations, severe shocks, or heavy loads.

Check (✓) the correct statement(s) below.

_____1. Soldering and welding are the same.

_____2. Solder is an alloy and must melt at a higher temperature than the base metals.

_____3. Solder joints can be relied upon for strength.

_____4. In soldering, the coated base metals are sweated together by the use of heat.

Frame 24

Soft solder is a mixture of tin and lead. There are as many types of solder as there are combinations of tin and lead. However, the Air Force uses only a small number of these combinations. The three most commonly used ratios are 40/60, 45/55 and 50/50. The tin content is represented by the first number. More tin causes the solder to be harder and to crystalize and break easily. Solder with more lead than tin will be soft, but not very strong.

Check (✓) the correct statement(s) below.

_____1. More tin than lead makes solder soft.

_____2. 60/40 solder would be harder than 40/60 solder.

_____3. Soft solder crystalizes easily and will break.

_____4. The tin content of solder is represented by the last number.

Answers to Frame 23: _____1. _____2. _____3. __✓__4.

Frame 25

Soft solder is the type of solder used in the maintenance of electrical/electronic equipment and other jobs requiring small amounts of solder. This type of solder is made in plain solid wire/block form (figure 11) or it may have a hollow core filled with either rosin or acid (figure 12). Acid core solder is NEVER used in electrical/electronic maintenance for it is very corrosive. Hard solder (silver alloy) used in the soldering of thermocouple wires (exhaust gas temperature indicating system), will not be covered in this text.

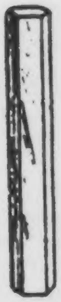


Figure 11.

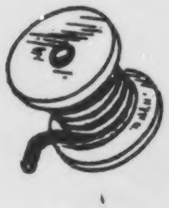


Figure 12.

Check (✓) the correct statement(s).

_____1. Acid core solder should not be used in electrical wire maintenance.

_____2. Soft solder would be used in the maintenance of thermocouple wires.

_____3. Rosin core solder is very corrosive.

Answers to Frame 24: _____1. __✓__2. _____3. _____4.

Most metals which have been exposed to the atmosphere will acquire a thin film of tarnish or oxide. The longer the period of exposure, the thicker the film will become. This film, even though it may not be visible, is a poor conductor of heat and must be removed for proper soldering. The solder alone cannot dissolve or remove this film. A solder flux (rosin core or rosin in paste form) with a melting point lower than the solder must be used to "wet" the metal and dissolve the film. The solder then melts, floating the lighter flux and impurities (oxide) to the outer surface of the molten solder.

Check (✓) the correct statement(s).

_____1. The atmosphere will cause most metals to tarnish.

_____2. The tarnish film on metal is a good conductor of heat.

_____3. The solder's melting point is higher than that of the flux.

_____4. Flux removes the oxide by dissolving it.

Answers to Frame 25: __✓__1. _____2. _____3.

Frame 27

The flux (rosin) is a chemical reducer used for surface conditioning during the soldering process. Have you ever watched the play of colors on a piece of metal as it heats? This display of color is due to electrons in the hot metal being heated off the metal. To regain these electrons, the metal combines with oxygen in the air and begins to form an oxide coating on the surface of the metal. By disolving the oxide (poor heat conductor) on the surface of the metal, the flux cleans the surface. The solder, in its molten state, will now cling to the part of the metal surface being soldered.

Check (✓) the correct answer(s).

A flux is used on a surface to be soldered to

_____1. soften the solder.

_____2. smooth the surface before soldering.

_____3. get oxygen to the surface of the metal.

_____4. clean the surface by dissolving the oxide formation.

Answers to Frame 26: __✓__1. _____2. __✓__3. __✓__4.

Frame 28

Cleanliness is of the utmost importance in soldering operations. If possible, soldering should be done in an area that is reasonably clean and free from excessive dust. Drafty areas should be avoided so that the soldering iron will not cool. A soldering job on an aircraft on a cold windy day may require that the aircraft be pulled into the hangar or dock area. Surfaces contaminated with dirt, oil, grime or grease cannot be successfully soldered. Make sure that the surfaces are mechanically "bright-clean" before soldering. Clean the surfaces with a cloth dipped in alcohol, trichlorethylene, or other approved solvent. Old solder should be removed from a surface.

Three ways that old solder can be removed from a surface are by heating the solder until it melts, then, (1) wipe it off with a cloth; (2) tilt the work and tap it lightly; and (3) draw the solder off with the iron and an excess piece of wire called (wicking).

Make a check (✓) by the correct statements.

_____1. Contaminated surfaces should be cleaned before soldering is attempted.

_____2. Successful soldering operations depend on cleanliness and a properly heated soldering iron.

_____3. Old solder on a surface may be used in the new soldering job.

_____4. A dusty, drafty area is not an ideal place to do soldering.

Answers to Frame 27: _____1. _____2. _____3. __✓__4.

Frame 29

A neat soldering job means only one thing--it was done correctly! The soldering iron melted the solder quickly and the solder flowed into and around the surfaces, and then hardened into place without including air bubbles, oxides or other foreign matter. Soldering irons (figure 13) come in various sizes and shapes. The one you will use in this course is well suited for the work you will do. However, your work on the flight line may require you to make a choice as to size of tip, wattage and voltage (28 VDC or 115 VAC 60 Hz).

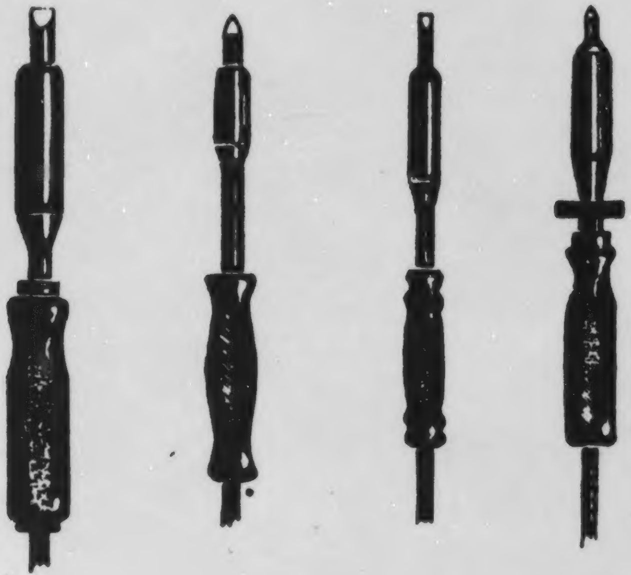


Figure 13.

No Response Required

Answers to Frame 28: __✓__1. __✓__2. _____3. __✓__4.

Frame 30

Soldering will not be required every time you have a broken electrical wire. In some instances where electrical wires are broken, solderless connectors can be used. Of the many types and sizes, only the solderless terminal lug (figure 14) and splice (figure 15) for small copper electrical wires will be covered. Electrical wires are terminated (ended) with terminal lugs to permit easy and efficient connection to and disconnection from terminal boards, busbars, and other electrical equipment. Splices join electrical wires to form permanent continuous wire runs.

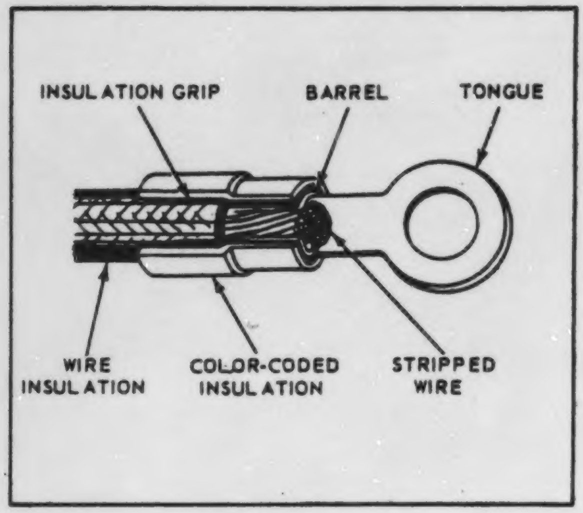


Figure 14.

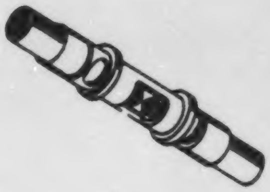


Figure 15.

Check (✓) the correct statement(s).

_____1. Solderless terminal lugs permit easy connection and disconnection of electrical wiring.

_____2. Solderless splices permit electrical equipment to be disconnected more easily.

_____3. Terminal lugs terminate wires, and splices form continuous runs by joining wires together.

Frame 31

Solderless terminal lugs and splices are made of copper or aluminum. They are preinsulated or uninsulated depending on where they are to be installed. Again, due to the many types, sizes and different installation procedures, the preinsulated copper solderless connectors will be the only one covered in this text. Technical Order 1-1A-14 should be consulted when using solderless connectors of a specific type for a specific application.

Caution: Use only copper solderless connectors on copper wire; aluminum connectors on aluminum wire. Connecting two different materials together aids in the corrosion process.

Check (✓) the correct statement(s).

_____1. All solderless terminal lugs are copper and preinsulated.

_____2. Copper solderless connectors are not used on aluminum wire.

_____3. Solderless splices are aluminum and always uninsulated.

_____4. Of the many types and sizes of solderless connectors, the installation procedures are the same for all.

Answers to Frame 30: __✓__1. _____2. __✓__3.

Frame 32

For installing small copper wire preinsulated solderless connectors in the number 26 through the number 10 wire size, a hand crimping tool is used. In figure 16, notice the information listed on the "Instruction Plate" of the tool.

Note: You may use the actual tool to read the "Instruction Plate" more easily.

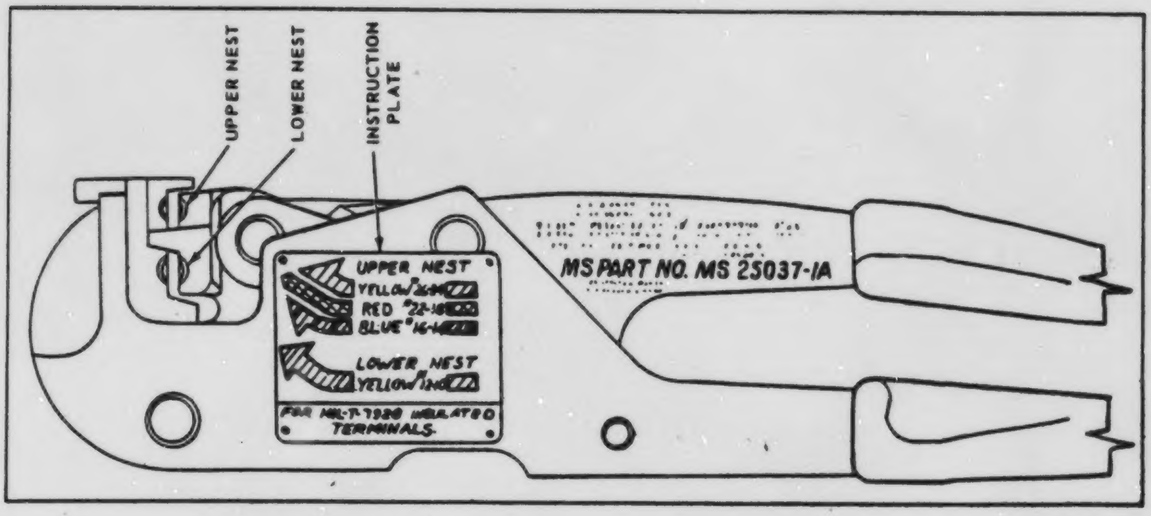

UPPER NEST
LOWER NEST
INSTRUCTION PLATE
UPPER NEST
YELLOW #26-24
RED #22-18
BLUE #16-14
LOWER NEST
YELLOW #12-10
FOR MIL-T-7928 INSULATED TERMINALS.
MS PART NO. MS 25037-1A

Figure 16.

Observe figure 16 (or the tool) and complete the following statement.

For crimping a solderless connector to a size 18 wire, the __________ nest of the crimping tool should be used.

Answers to Frame 31: _____1. _✓_2. _____3. _____4.

Frame 33

The correct answers will be listed after the last review question.

Check (✓) the correct answers below.

1. Soldering is the process of

_____a. binding two metals together.
_____b. fusing metals together.
_____c. welding metals together.
_____d. bonding tinned surfaces by the use of heat.

2. Soft solder is an alloy of

_____a. tin and copper.
_____b. copper and lead.
_____c. tin and lead.
_____d. lead and silver.

3. In soldering electrical wires, you would NEVER

_____a. remove old solder.
_____b. use acid core solder.
_____c. be concerned about oxide formation.
_____d. use a 28 VDC soldering iron.

4. Flux is used on a surface to be soldered to

_____a. smooth the surface.
_____b. soften the solder.
_____c. clean the surface by dissolving oxide formation.
_____d. get oxygen to the surface of the metal being soldered.

5. The most important thing in a soldering operation is

_____a. cleanliness.
_____b. soldering sequence.
_____c. soldering iron selection.
_____d. a "feel" for the work.

Answers to Frame 32: upper

6. Solderless connectors for small copper wires are installed by using

_____a. wire stripping tool.

_____b. hand crimping tool.

_____c. duckbill plier tool.

_____d. diagonal cutter tool.

7. For the installation of small copper preinsulated solderless connectors, the tool can be used with wire size ranges of

_____a. #10 - #26.

_____b. #8 - #26.

_____c. #10 - #24.

_____d. #8 - #24.

Frame 34

You have now completed the programmed text. If you had any problems or did not understand something, go back and review the frames that cover that material. If you still have problems, contact the instructor. After you understand all the material, you may take the appraisal covering all three sections of the text. After satisfactory completion of the appraisal you will proceed to the maintenance lab to complete the workbook covering torque wrenches, safetying devices, soldering and solderless connectors.

No Response Required

Answers to Frame 33:

	a.	b.	c.	d.
1.				✓
2.			✓	
3.		✓		
4.			✓	
5.	✓			
6.		✓		
7.	✓			

PROGRAMMED TEXT

3ABR32531-PT-201
3ABR32632B-PT-301

Technical Training

Avionic Instrument Systems Specialist
Integrated Avionic Systems Specialist

POSITION INDICATING SYSTEMS

10 August 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

433

FOREWORD

This programmed text was prepared for use in Courses 3ABR32531, Avionic Instrument Systems Specialist, and 3ABR32632B, Integrated Avionic Systems Specialist. This text has been validated using 23 students from the subject courses. Twenty-three of the students achieved the objective as stated. Average completion time is 120 minutes.

OBJECTIVE

Without references, identify facts pertaining to the purpose, operation, and/or characteristics of typical position indicating systems with an accuracy of at least 80%.

INSTRUCTIONS

This programmed text is divided into three sections: Section A covers wheel position indicating systems (3ABR32531 and 3ABR32632B), Section B covers Flap Position Indicating Systems (3ABR32531 ONLY), and Section C covers control surface position indicating systems (3ABR32632B ONLY). The information presented in this text is presented in small steps called "frames." After reading the information in each frame you are asked to actively respond to the statements at the end of that frame. Place these responses on the response sheet provided with this text. Check your responses for accuracy with the correct answers given after the following frame. If you make an incorrect response, reread the frame until you determine why you were in error before proceeding to the next frame. After completing each required section of your course you will take an appraisal to display your attainment of the stated objective before proceeding to the next area of instruction. Work as quickly as possible, but DO NOT RUSH!

Supersedes 3ABR32531-PT-202, 12 December 1974; 3ABR32531-PT-203, 13 April 1973; 3ABR32632B-PT-304B, 18 April 1975.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 200; TTVSR - 1

45

Section A

(3ABR32531 and 3ABR32632B)

Frame 1

The early military aircraft had fixed landing gear; that is, the gear was not retractable. As the aircraft was improved and airspeed increased, it was found that the gear caused unwanted drag on the aircraft, slowing it down. Retractable gear was developed and used to help streamline the aircraft, thus reducing drag and increasing speed.

Figure 1 shows an aircraft with fixed gear and figure 2 with retractable gear.

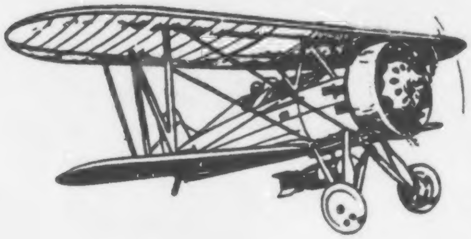


Figure 1.

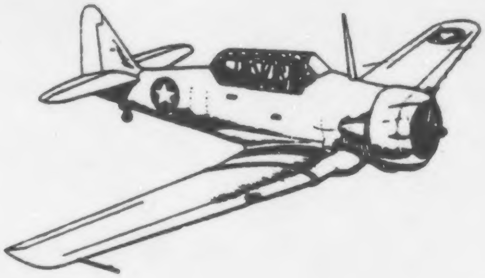


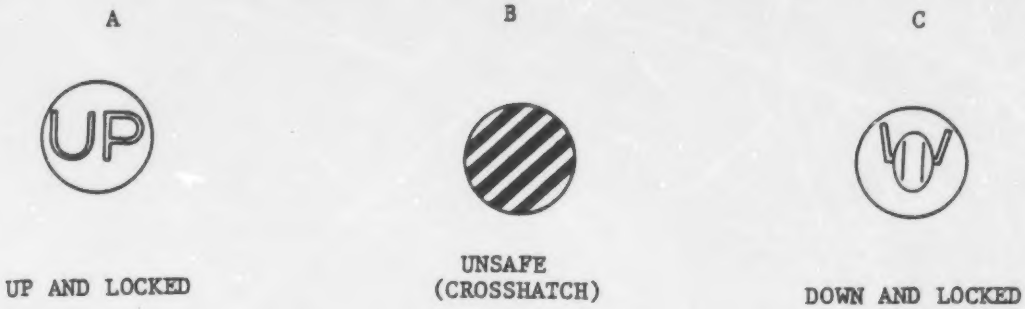
Figure 2.

NO RESPONSE REQUIRED

435.

Frame 2

With the development of the retractable landing gear, an indicating system was developed to indicate the position of the gear. This system was designed to display the three main positions of the gear. Figure 3 below shows the three displays. In drawing A the gear would be UP and locked, drawing B, the gear would be unsafe (crosshatch) and in drawing C the gear would be down and locked.



UP AND LOCKED

UNSAFE
(CROSSHATCH)

DOWN AND LOCKED

Figure 3.

Circle the correct response/s to the following statements.

1. With the landing gear up and locked, which one of the symbols would show on the indicator? Use figure 3 if needed.

    a. Word "UP."

    b. Crosshatch.

    c. Picture of landing gear.

45

Answers to Frame 1: NO RESPONSE REQUIRED.

Most aircraft have three landing gears, for each gear there are two microswitches and one indicator. Figure 4 is a schematic for one gear of a typical three landing gear system. The landing gear indicating system is operated from the aircraft's 28V DC power system. When the gear closes either of the microswitches the corresponding solenoid coil in the indicator will be energized by 28V DC and the indicator will display the position of the gear.

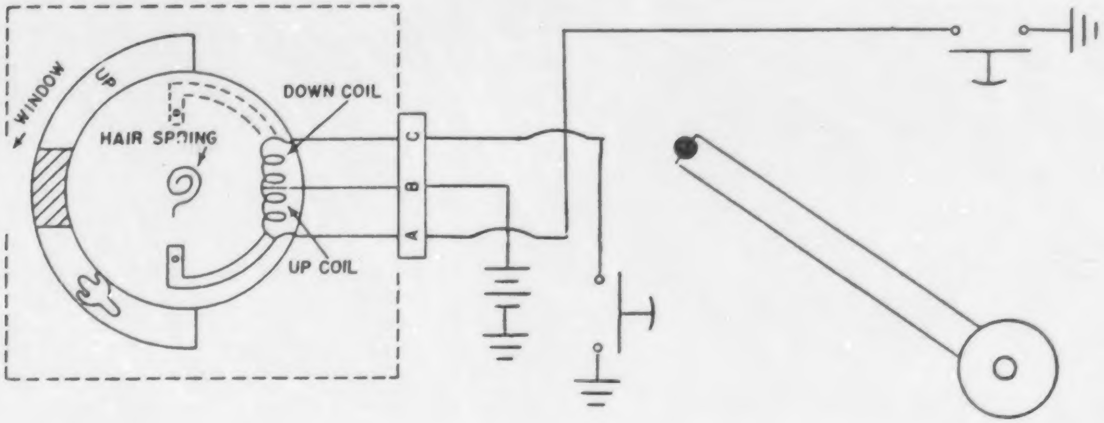


Figure 4.

Circle the correct response/s to the following statements.

1. When the UP microswitch is closed, the voltage on the UP coil is

   a. 0V DC.

   b. 12V DC.

   c. 24V DC.

   d. 28V DC.

2. Which one of the indications would appear on the indicator when the down microswitch is closed?

   a. UP.

   b. Crosshatch.

   c. Picture of gear.

Frame 3 (Continued)

3. The microswitches are closed by the

   a. landing gear handle.

   b. landing gear.

   c. pilot.

   d. solenoid coil.

Answers to Frame 2: 1. a

The indicating drum of the indicator has two soft iron cores attached to it. Whenever either microswitch is closed and that coil energizes, one of the iron cores is attracted into the energized coil. This increases the magnetic field of the coil. As the iron core is pulled into the coil the indicating dial is rotated to indicate the position of the gear and will remain in that position until the microswitch is opened by the movement of the gear. The indicating drum also has a hairspring attached to it to return the drum to the neutral (crosshatch) position whenever power is removed from the coils.

SEE figure 5 below.

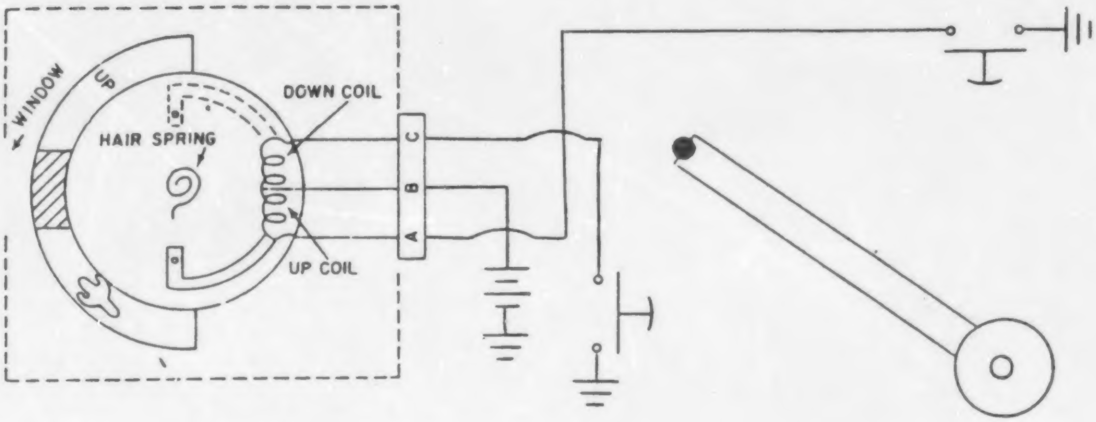


Figure 5.

Circle the correct response/s to the following statements.

1. When either coil becomes energized, the indicator operates on the principle of magnetic

   a. interaction

   b. repulsion

   c. attraction

   d. correlation

2. With the UP microswitch closed, which coil is energized and what will the indicator display?

   a. Up solenoid coil and picture of gear.

   b. Up solenoid coil and word "UP."

   c. Down solenoid coil and picture of gear.

   d. Down solenoid coil and word "UP."

Frame 4 (Continued)

3. The hairspring will cause what indication to appear when power is removed from the system?

   a. "UP."

   b. Crosshatch.

   c. Picture of gear.

Answers to Frame 3: 1. d 2. c 3. b

Frame 5

When the pilot moves the landing gear to the down position the down microswitch activates as the gear locks into place. This in turn completes the circuit and energizes the down coil with 28V DC. This coil then pulls the down iron core into it causing the picture of the gear to be displayed by the indicator. SEE figure 6 below.

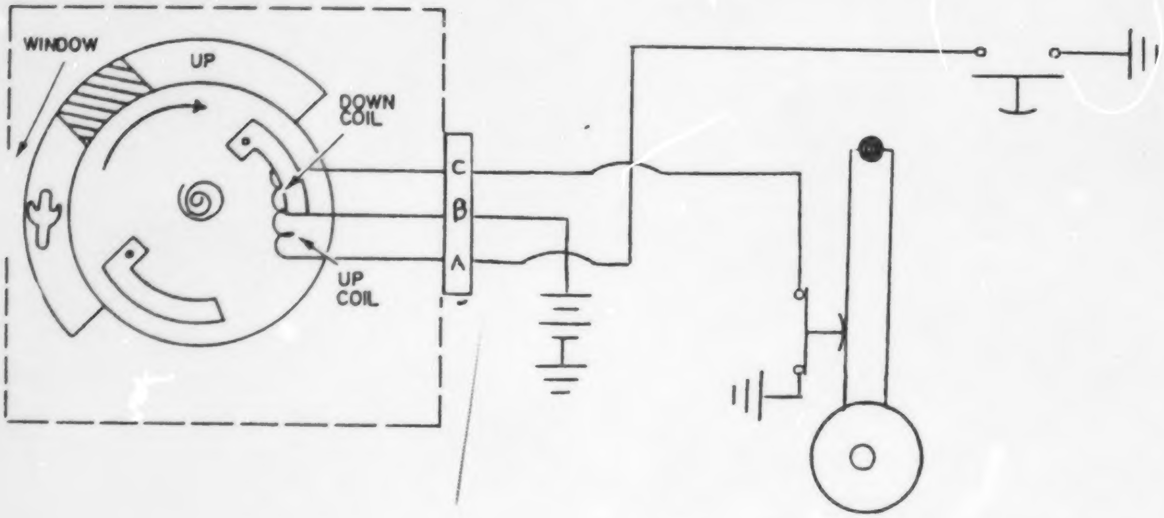


Figure 6.

Circle the correct response/s to the following statement.

1. When the gear is down and locked, which microswitch is closed and what indication is displayed?

   a. Up microswitch and the word "UP."

   b. Up microswitch and picture of the gear.

   c. Down microswitch and word "UP."

   d. Down microswitch and picture of the gear.

Answers to Frame 4: 1. c 2. b 3. b

Frame 6

As the landing gear begins to retract the down microswitch breaks contact, deenergizing the down solenoid coil thus removing power from the circuit. At this time the hairspring will return the indicating drum to the crosshatch position. This lets the pilot know that the gear is in an unsafe position. SEE figure 7 below.

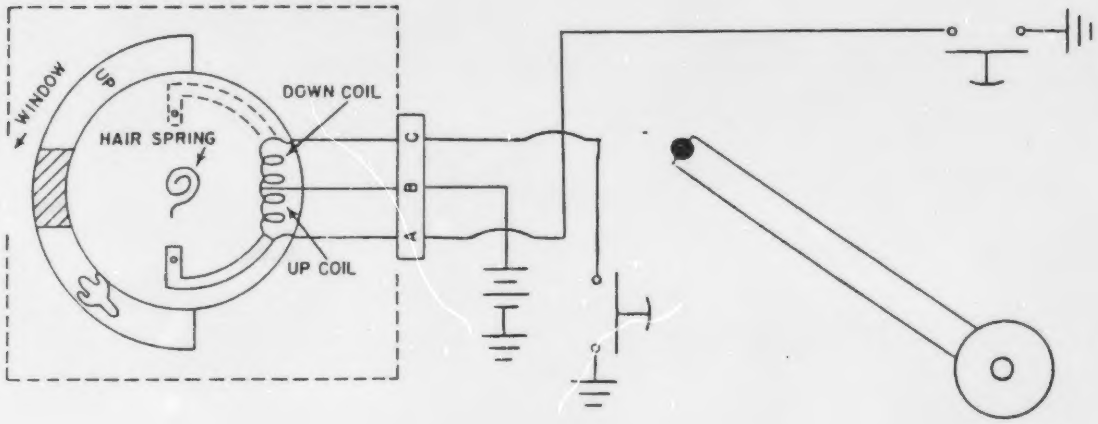


Figure 7.

Circle the correct response/s to the following statements.

1. When the landing gear is moving what indication is displayed?

   a. "UP"

   b. Crosshatch

   c. Picture of gear.

Answer to Frame 5: 1. d

When the landing gear reaches the Up and locked position the Up microswitch will close and energize the Up coil. The coil then pulls the Up iron core into it rotating the indicating dial to the "UP" indication. See figure 8 below.

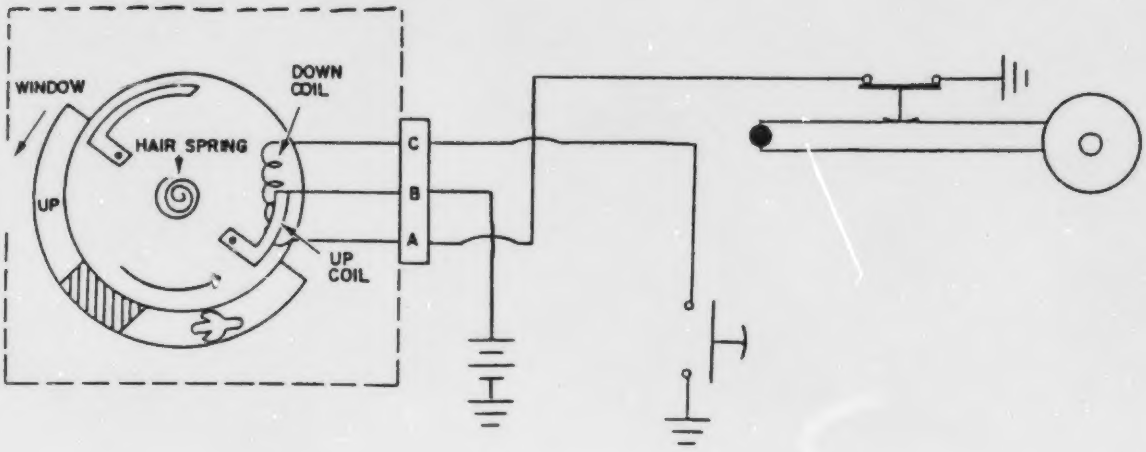


Figure 8.

Circle the correct response/s to the following statements.

1. With the landing gear retracted, the indicator would display what indication?

   a. Picture of gear.

   b. Word "UP"

   c. Crosshatch

Answers to Frame 6: 1. b

443

Frame 8

Circle the correct response/s to the following statements.

1. The landing gear indicating system operates by

   a. 12V DC.

   b. 28V DC.

   c. 28V AC.

   d. 36V AC.

2. The purpose of the landing gear indicating system is to indicate when the gear is

   a. unsafe.

   b. up and locked.

   c. down and locked.

   d. up and locked, down and locked, and unsafe.

3. When voltage is applied to either of the solenoid coils, the soft iron core is pulled to the energized coil by

   a. repulsion.

   b. hairspring.

   c. counterbalance.

   d. magnetic attraction.

4. When voltage is removed from the solenoid coils the indication will be

   a. UP.

   b. crosshatch.

   c. picture of gear.

5. With the landing up microswitch closed, the indicator should indicate the

   a. UP.

   b. crosshatch.

   c. picture of gear.

4[illegible]

6. When voltage is removed from coils, the drum rotates to the neutral position due to

   a. magnetic repulsion.

   b. magentic attraction.

   c. hairspring tension.

   d. counter balance action.

7. Using figure 9, which coil will energize with the landing gear in the down position?

   a. Up coil.

   b. Down coil.

   c. Both coils.

   d. Neither coil.

8. Using figure 9, if the down microswitch remained closed when the landing gear retracted, the indication would be

   a. word "UP."

   b. crosshatch.

   c. picture of gear.

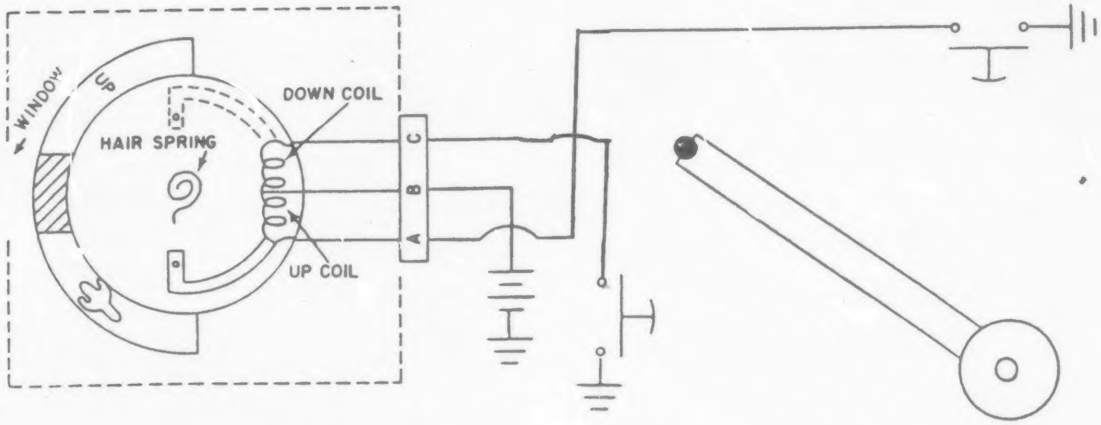


Figure 9.

Frame 8 (Continued)

Match the functions from Column B to their name in Column A by placing the correct letter in the blank provided.

Column A		Column B
9._____ Up solenoid coil	a.	closed when landing gear is down.
10._____ Up microswitch	b.	attracted to solenoid coils when either coil energizes.
11._____ Indicating drum	c.	28V DC power source.
12._____ Hairspring	d.	closed when landing gear is up.
13._____ Soft iron cores	e.	keeps crosshatch in view when power is removed.
14._____ Down solenoid coil	f.	energized when down switch is closed.
15._____ Down microswitch	g.	energizes when up switch is closed.
	h.	rotated to display crosshatch, up, and gear.

Answers to Frame 7: 1. b

Answers to Frame 8: 1. b 2. d 3. d 4. b 5. a 6. c

7. b 8. c 9. g 10. d 11. h

12. e 13. b 14. f 15. a

Section B

(3ABR32531 ONLY)

Frame 1

As aircraft became larger and heavier, a wing flap system was added to the wing to increase lift for take off and increase drag for landing. With this addition a system was developed to display the position of the wing flaps to the pilot. The system that was found to be the most practical system was the self-synchronous indicating system. The self-synchronous system is known as the selsyn system. This system is made up of a transmitter and an indicator Figure 1 shows a diagram of a selsyn system.

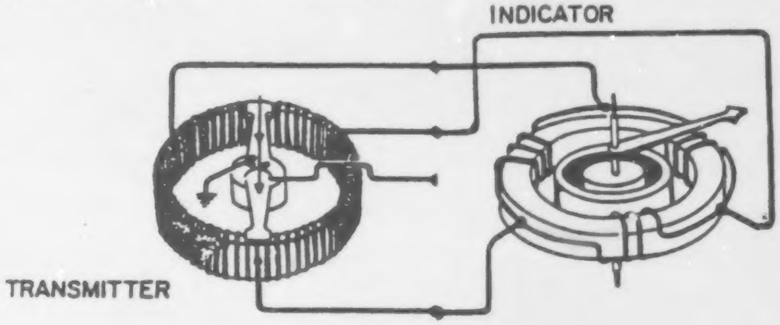


Figure 1.

Refer to figure 1 and circle the correct answer to the following statements.

1. The flap position indicating system consists of a

   a. transmitter and flap.

   b. indicator and flap.

   c. transmitter and indicator.

   d. transmitter and control handle.

2. The flap position indicating system indicates the position of the

   a. aileron flaps.

   b. wing flaps.

   c. elevator flaps.

   d. rudder flaps.

Frame 2

The flap position is displayed on an indicating dial with a pointer. The dial is graduated in 5° increments from an "UP" position to a "DOWN" position with the number of degrees dependent on the aircraft in which it is to be used. The pointer, when referenced to the dial, will display the extent of travel (movement) of the wing flaps. Refer to figure 2 and notice the position of the pointer. A small "Pull Off" magnet, located in the indicator will reposition the pointer to this position (Off Scale Up) whenever power is lost to the system. This is done to prevent a false indication to be displayed on the indicator when the system is without power. Power requirement for this system is 28VDC.

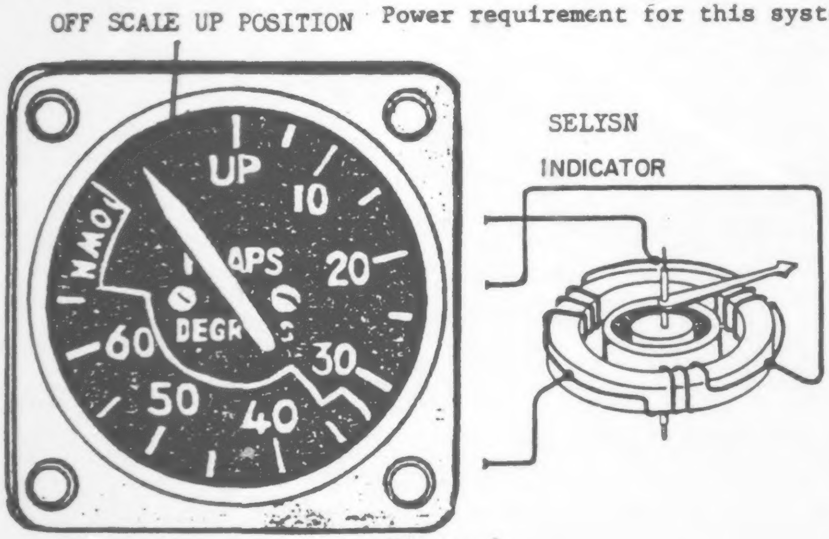


Figure 2.

Circle the correct response to the following statements.

1. The wing flap indicator is marked in

   a. inches. c. 2° increments.

   b. feet. d. 5° increments.

2. The "Pull Off" magnet will prevent the indicator from giving a false reading by

   a. smoothing out rotor operation.

   b. preventing rotor overtravel.

   c. preventing rotor undertravel.

   d. pulling pointer off scale up when power is lost.

Answers to Frame 1: 1. c 2. b

Frame 3

The indicator diagram below shows a circular soft iron core with three coils equally spaced around the core. Each coil tapoff (A, B, and C) is connected by wires to transmitter tapoff tie points. The rotor is a permanent magnet and is used to reposition the pointer.

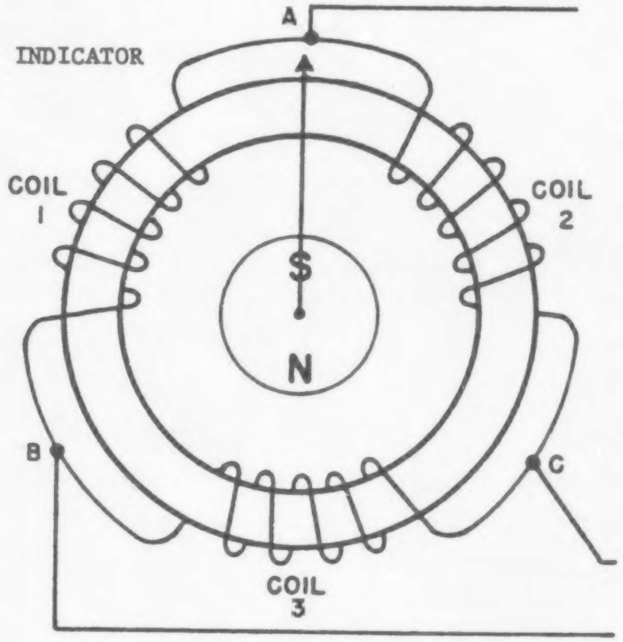


Figure 3.

Study figure 3 and check the true statement(s).

1. Coils 1, 2, and 3 are wound on a

   a. circular iron core.

   b. triangular iron core.

   c. square brass core.

   d. circular brass core.

Answers to Frame 2: 1. d 2. d

449

Frame 4

As current flows through the coils, north and south poles are set up on each coil which will rotate the rotor and pointer to indicate the position of the wing flaps. In the figure below, terminals "A" and "C" are the negative terminals and terminal "B" is the positive terminal. Since current flows from negative to positive, coils 1 and 3 have current flow through them. The rotor and pointer in this figure have not been drawn at the position that corresponds with the magnetic fields of the coils.

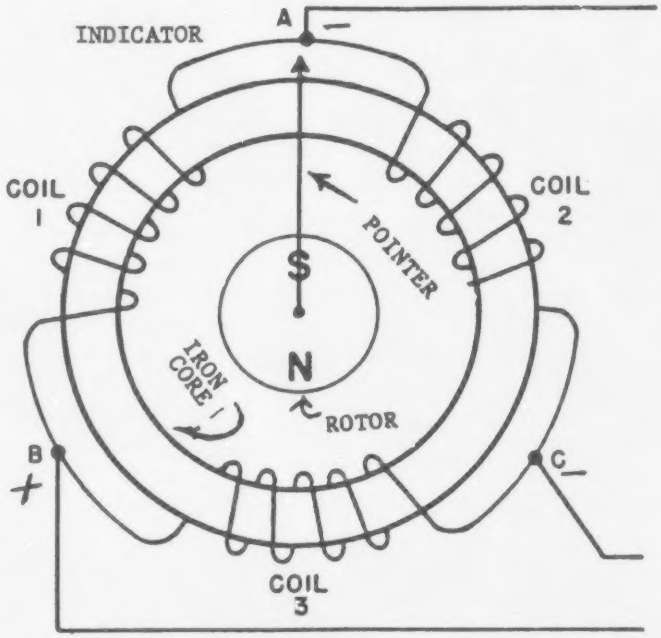


Figure 4.

Study figure 4 and check the following statement(s) that are true.

1. The coils that have current flow through them are

   a. 1 and 2.

   b. 2 and 3.

   c. 1 and 3.

471

Answers to Frame 3: 1. a

The transmitter is located in the wing flap section of the aircraft wing. When the wing flap is extended or retracted, a mechanical linkage turns the shaft on the transmitter. The transmitter is connected to an indicator by an electrical connector and wires. Refer to figure 5 for a picture and schematic of the selsyn type transmitter.

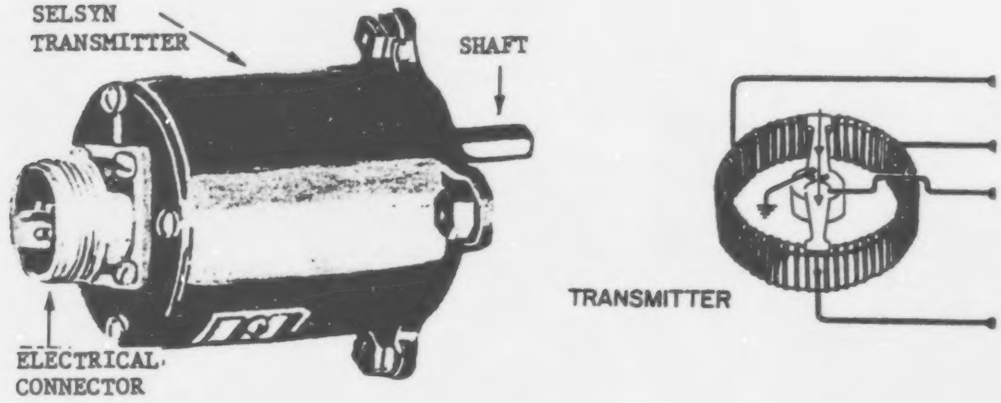

SELSYN TRANSMITTER
SHAFT
ELECTRICAL CONNECTOR
TRANSMITTER

Figure 5.

Refer to figure 5 and check the true statement(s).

1. The wing flap transmitter is connected to the wing flap by

   a. electrical connections.

   b. hydraulic connections.

   c. mechanical linkage.

Answers to frame 4: 1. c

Frame 6

The flap transmitter selsyn is made up of a circular resistance strip and positive and negative wiper arms. These arms are mounted on a shaft and are insulated from each other in order to prevent short circuits. As the shaft is turned by a mechanical linkage, both arms turn at the same time and each travel equal distances. This unit is actually a potentiometer to control voltage. Refer to figure 6 for the diagram of the transmitter.

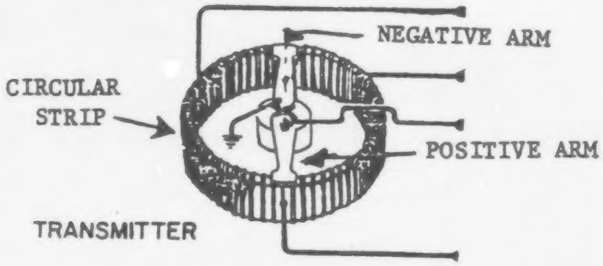


Figure 6.

Refer to figure 6 and check the true statement(s).

1. As the transmitter shaft is turned, the wiper arms move

   a. at the same time and equal distances.

   b. individually and equal distances.

   c. at the same time and unequal distances.

   d. individually and unequal distances.

2. The transmitter unit is basically a

   a. ammeter.

   b. potentiometer.

   c. rheostat.

Answers to Frame 5: 1. c

For explanation purposes, 24 volts is used in the following frames to eliminate fractions or decimals in your calculations. The resistance strip has three taps that are located 120° apart. This unit is actually a simple voltage divider. Referring to figure 7, notice that point "B" is two thirds of the distance between the negative and positive wiper arms. Point "C" is also two-thirds of the distance between the negative and positive wiper arms. Since point "B" is two-thirds of the distance between the - and + wiper arms, two-thirds of the applied voltage is dropped between the - wiper arm and point "B." The other one-third of the voltage is dropped between point "B" and the positive wiper arm. By connecting voltmeters between the negative wiper arm and "B," and the positive wiper arm and "B," you would read "16"V and "8"V respectively. The same readings are also found at point "C" because "C" was also two-thirds of the distance between the negative and positive wiper arms.

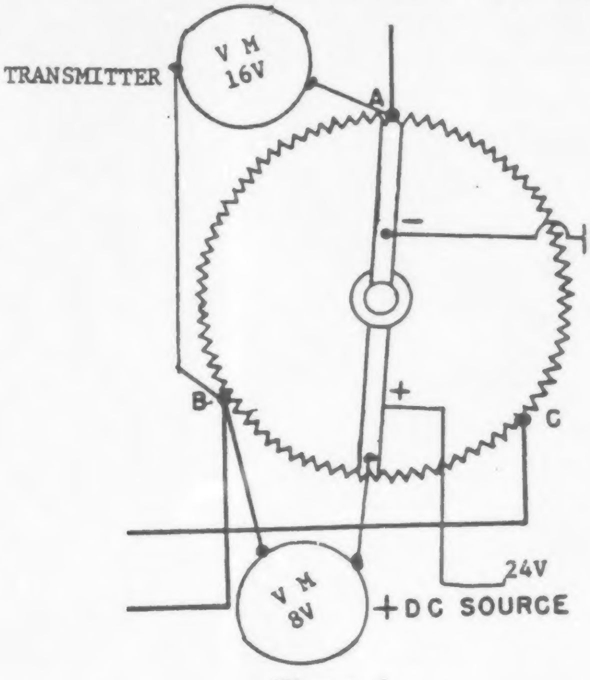


Figure 7.

1. A voltmeter connected between the negative wiper arm and point "C" would indicate how much voltage?

   a. 0V.

   b. 8V.

   c. 16V.

   d. 24V.

Answers to Frame 6: 1. a 2. b

453

Frame 8

The three coils in the indicator are connected to the transmitter taps as shown in figure 8. Since 0 volts are applied to the negative wiper arm, this 0 volts will be applied to terminal "A" of the indicator. Terminals "B" and "C" of the transmitter are two-thirds the distance between the negative and positive wiper arms. With point "A" (0V) being more negative than points "B" and "C" (16V), current will flow through coil 1 to point "B" and through coil 2 to point "C." Using the left-hand method (see note below) the top of coil 1 and coil 2 will be north poles and will attract the pointer (south end of permanent magnet).

Note: The left hand rule says that in wrapping the left hand fingers in the direction of the current flow in the coil, your thumb will point to the north pole.

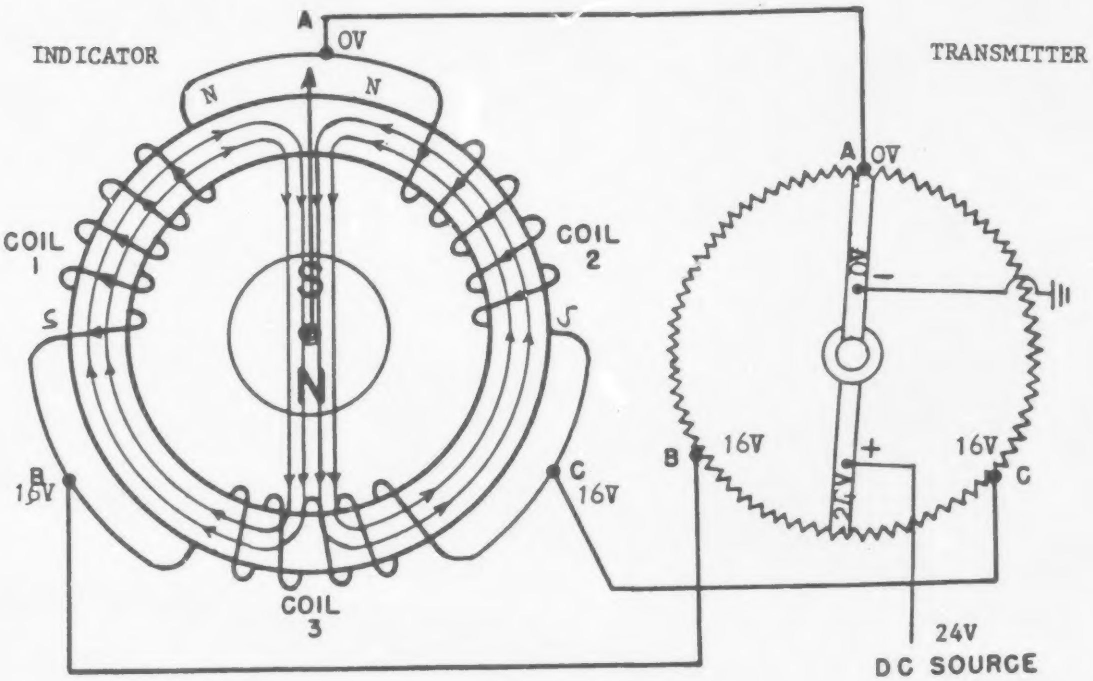

A
OV
INDICATOR
TRANSMITTER
N
N
COIL 1
COIL 2
S
S
S
N
B
16V
C
16V
COIL 3
A
OV
0V
−
+
24V
16V
16V
B
C
24V
DC SOURCE

Figure 8.

NO RESPONSE REQUIRED

Answers to Frame 7: 1. c

475

Frame 9

Using figure 9 below, circle the letter of the correct response to the following statements.

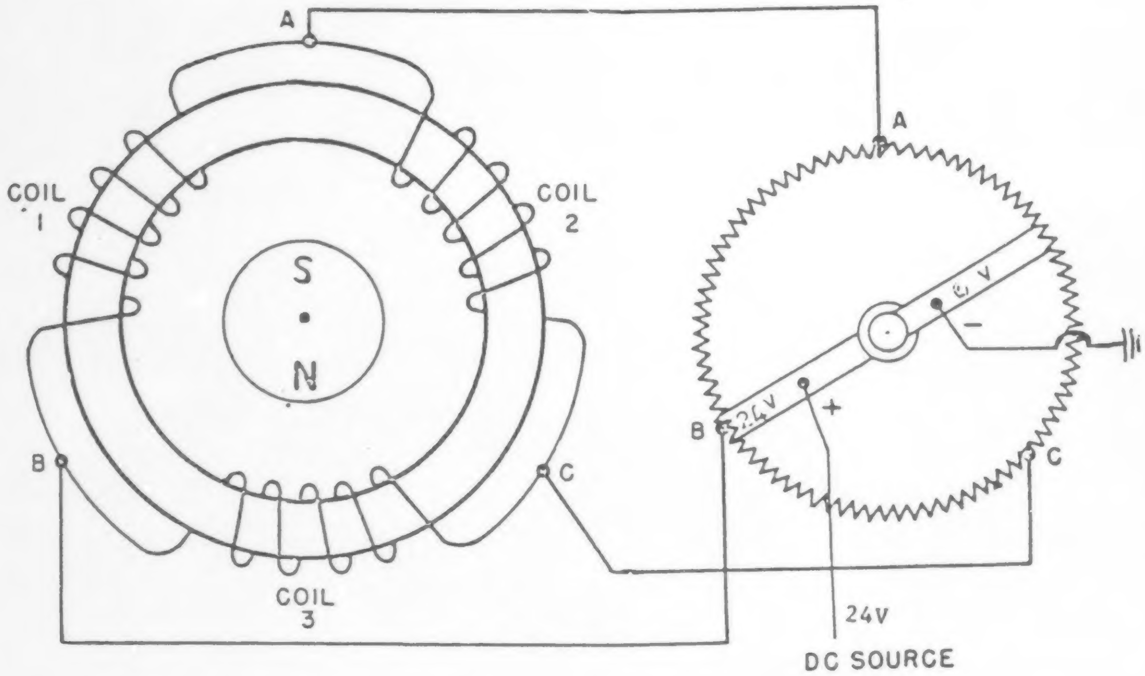

A
COIL
1
COIL
2
S
N
B
C
COIL
3
A
0 V
24V
+
−
B
C
24V
DC SOURCE

Figure 9.

1. With 24 volts applied to the positive wiper arm, how many volts will be at terminals "A" and "C" of the indicator?

   a. 0V.

   b. 8V.

   c. 16V.

   d. 24V.

2. Which two coils will have current flow through them?

   a. Coils 1 and 3.

   b. Coils 1 and 2.

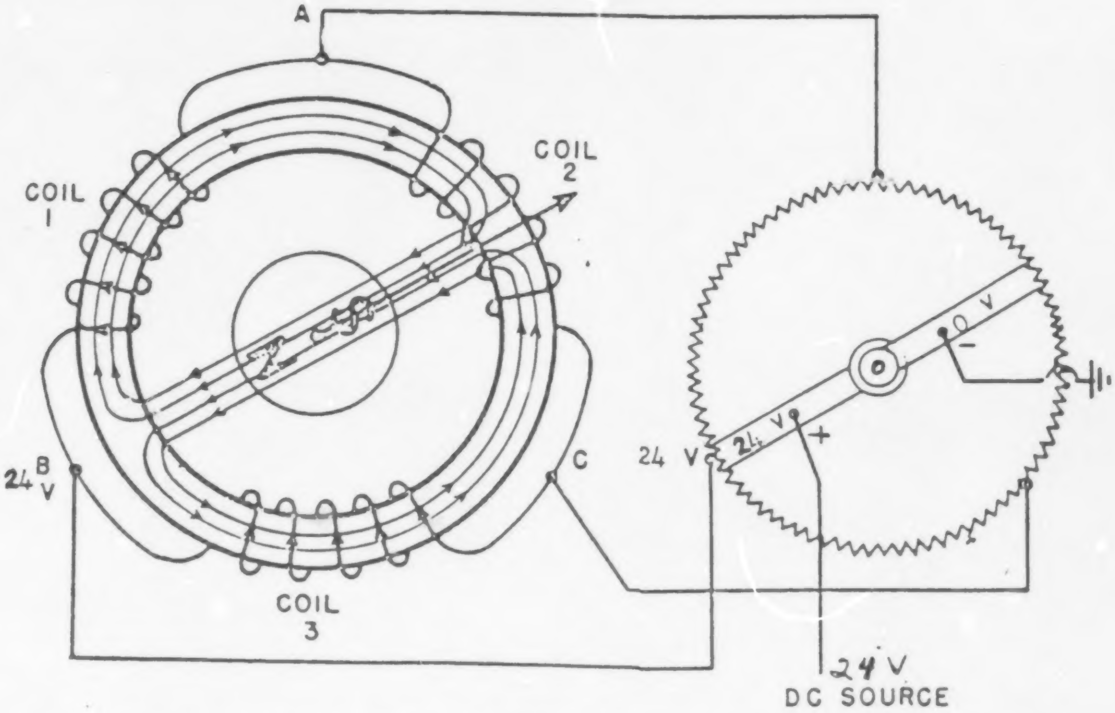
   c. Coils 2 and 3.

Frame 9 (Continued)

3. Refer to figure 9. After you have determined which coils have current flow through them, place the pointer in the indicator in the proper position. Use the diagram on your response sheet.

Answers to Frame 9: 1. b 2. a 3. Refer to page 25 for the answer.

3.


A
COIL 1
COIL 2
24 V B
C
COIL 3
24 V
24 V
0 V
+
−
24 V
DC SOURCE

Return to the beginning of the programmed text and review the objectives. When you are satisfied that you know and understand the material, you will take an appraisal.

3ABR32531 - After passing the appraisal, you will proceed to lab to perform on an actual flap position system.

457

Section C

(3ABR32632B ONLY)

Frame 1

In order to achieve the ability to adapt the F-111 fighter-bomber to any combat situation, it uses a wide variety of control surface configurations. To provide for a safe flight and completion of the mission, these control surfaces must be monitored continuously throughout the flight. As displayed by figure 1 below, there are seven control surfaces to be monitored and this is done by the use of two multi-display indicators.

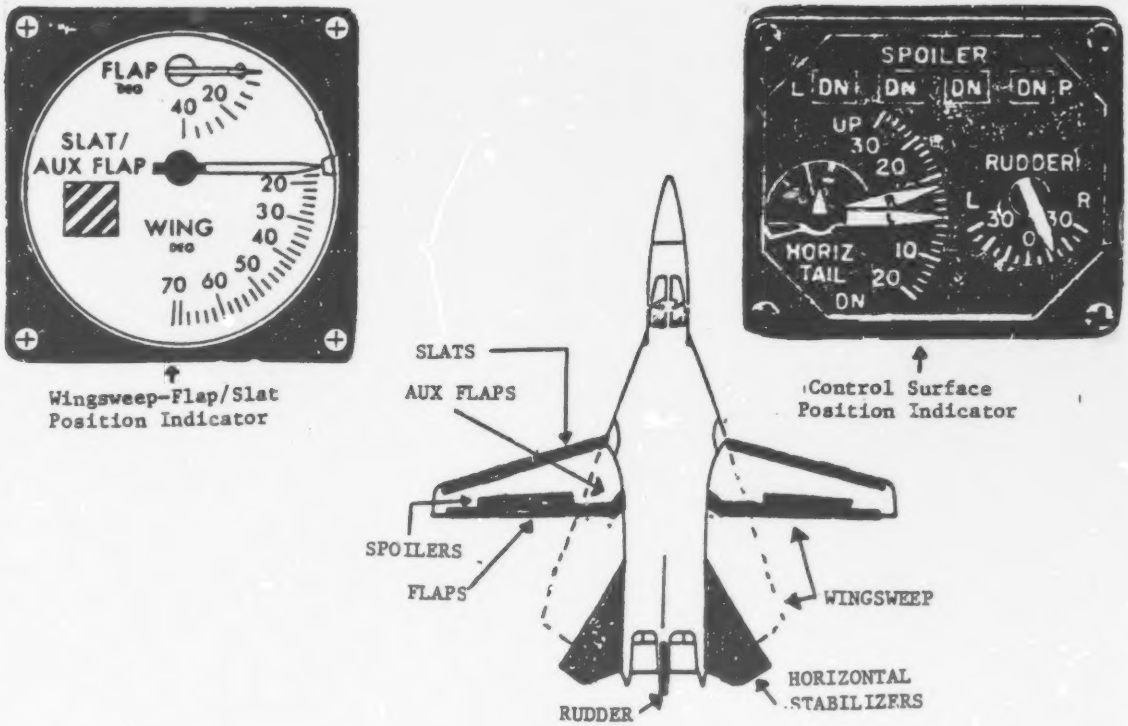

FLAP DEG
20
40
SLAT/ AUX FLAP
WING DEG
20
30
40
50
60
70
Wingsweep-Flap/Slat Position Indicator
SPOILER
L DN
DN
DN
DN R
UP
30
20
10
20
HORIZ TAIL DN
RUDDER
L
R
30
0
30
Control Surface Position Indicator
SLATS
AUX FLAPS
SPOILERS
FLAPS
WINGSWEEP
HORIZONTAL STABILIZERS
RUDDER

Figure 1.

Circle the letter of the correct response to the following statement.

1. Two multi-display indicators show the position of how many different control surfaces?

   a. 3

   b. 5

   c. 7

   - d. 9

The first of the two multi-display indicating systems that will be discussed is the wingsweep-flap/slat position indicating system. The purpose of this system is to provide a visual display of the desired wingsweep, actual wingsweep, flap position, and the slat/auxiliary flap position.

Circle the letter of the correct response to the following statement.

1. What does the wingsweep-flap/slat position indicating system indicate?

    a. Wingsweep position, flap position, and slat position.

    b. Desired wingsweep position, actual wingsweep position, flap position, and slat/aux flap position.

    c. Flap position, wingsweep position, and horizontal stabilizer position.

    d. Desired wingsweep position, desired flap position, and slat position.

Answer to Frame 1: 1. c

459

Frame 3

The wingsweep section of the system contains two indications displayed on a scale graduated from 16° to 72.5°. As shown below in figure 2, the two indications are desired wingsweep position, and actual wingsweep position. Each of the two indications is controlled by signals from a synchro transmitter.

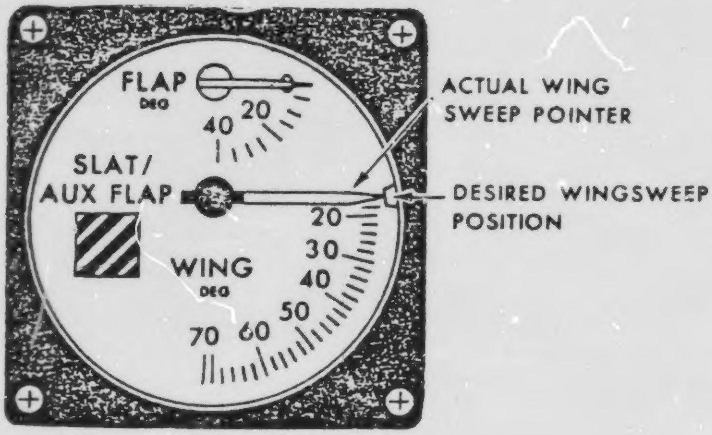

FLAP
DEG
20
40
SLAT/
AUX FLAP
WING
DEG
20
30
40
50
60
70
ACTUAL WING
SWEEP POINTER
DESIRED WINGSWEEP
POSITION

Figure 2.

Mark the following statements as TRUE (T) or FALSE (F).

_____1. The wingsweep portion of the indicator displays two indications.

_____2. The wingsweep scale is graduated from 16° to 72.5°.

_____3. Two synchro receivers are used for each indication.

491

Answers to Frame 2: 1. b

The desired wingsweep transmitter is a synchro transmitter and is located on the wing-flap position control box. The rotor of the transmitter will be mechanically repositioned whenever the pilot manually moves the wingsweep handle. See figure 3 below.

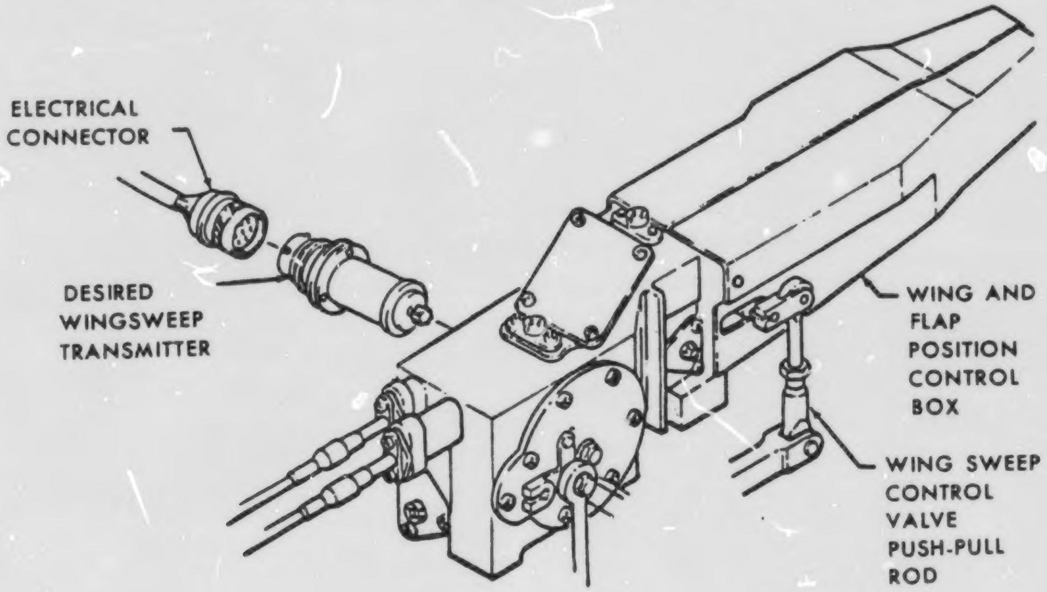

ELECTRICAL CONNECTOR
DESIRED WINGSWEEP TRANSMITTER
WING AND FLAP POSITION CONTROL BOX
WING SWEEP CONTROL VALVE PUSH-PULL ROD

Figure 3. Wing-Flap Position Control Box.

Mark the following statements as TRUE (T) or FALSE (F).

_____1. The desired wingsweep synchro-transmitter is repositioned by the wingsweep control handle.

_____2. The desired wingsweep transmitter is located on the wingsweep handle.

_____3. Desired wingsweep is selected by the pilot.

Answers to Frame 3: __T__ 1. __T__ 2. __F__ 3.

Frame 5

The wingsweep sensor (actual wingsweep transmitter) monitors the position of the wings by the use of a synchro-generator. This sensor is mounted at the left wing pivot and is repositioned by the wings as they are moving. See figure 4 below.

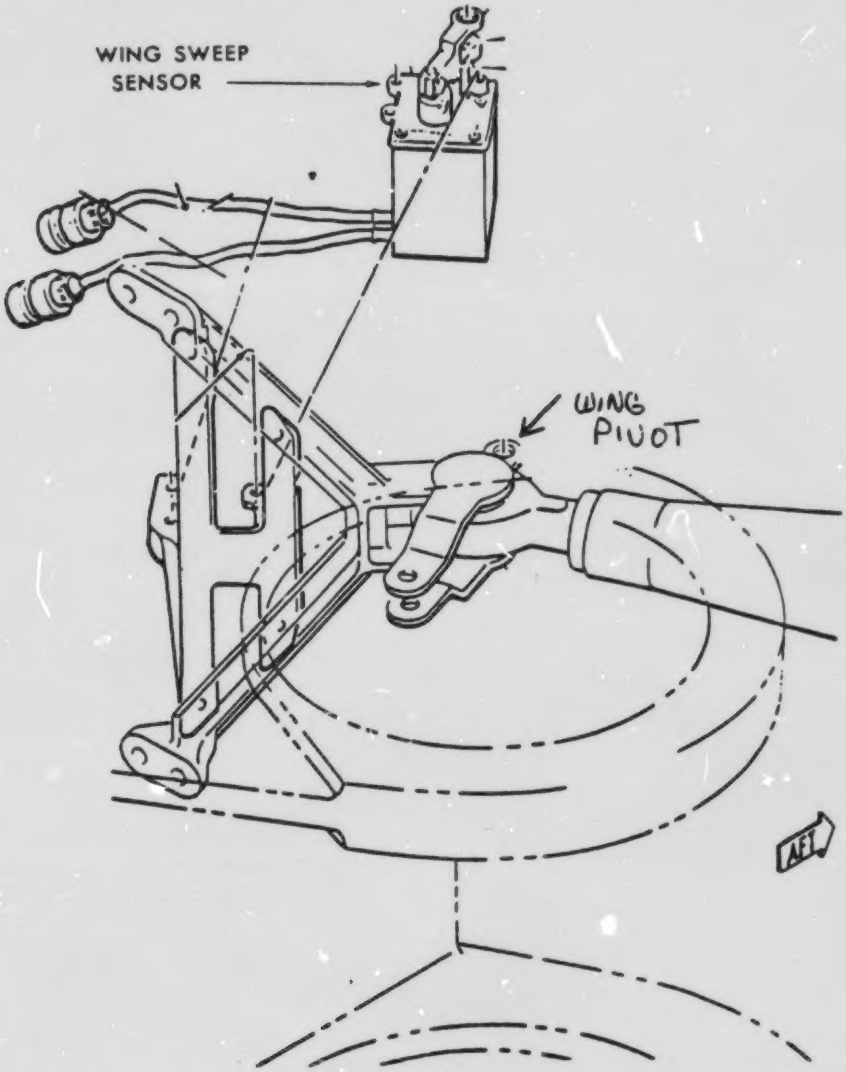

WING SWEEP SENSOR
WING PIVOT
AFT

Figure 4.

Circle the correct response to the following statements.

1. The wingsweep sensor contains a
   - a. magnetic sensor.
   - b. synchro generator.
   - c. synchro receiver.
   - d. soft iron core.
2. The wingsweep sensor is repositioned by the
   - a. wingsweep handle.
   - b. wing-flap position control box.
   - c. wings.
   - d. wingsweep hydraulic control valve.

Answers to Frame 4: __T__ 1. __F__ 2. __T__ 3.

463

Frame 6

Remove Handout 3ABR32632B-HO-302 (found at the end of this programmed text). Use figure 1 of Handout 3ABR32632B-HO-302 with the explanation of frame 6 and frame 7.

As the pilot moves the wingsweep control handle, the rotor of the desired wingsweep transmitter is mechanically repositioned. When this rotor is turned, the wye wound stator assembly senses a change in voltage which has been induced into each stator lead by transformer action. This change in voltage is transmitted to the stator leads of the receiver synchro in the indicator and sets up a new magnetic field. This magnetic field, through magnetic attraction, repositions the indicator rotor. When this rotor is turned, the desired wingsweep pointer is positioned, through mechanical linkage, to the position the pilot has selected. In this way the pilot can choose to what position the wings will be swept.

Circle the correct response to the following statement.

1. The indicator rotor is repositioned by

   a. magnetic repulsion.

   b. magnetic attraction.

   c. mechanical linkage.

   d. a gear train.

495

Answers to Frame 5: 1. b 2. c

Frame 7

Use figure 1 of Handout 3ABR32632B-HO-302 with the explanation in this frame.

At the same time the desired wingsweep signal is being transmitted to the desired wingsweep pointer, a hydraulic control valve is opened and the wings begin to move. As the wings move, the rotor of the wingsweep sensor is repositioned. The rotor then, through transformer action, induces different voltages into the three stator leads of the wingsweep sensor. This induced voltage of the stator leads is transmitted to the stator leads of the receiver synchro in the indicator. The indicator rotor is then turned by the magnetic fields set up by the indicator stators. This in turn places the actual wingsweep pointer to the position that agrees with the actual position of the wings.

Mark the following statements as TRUE (T) or FALSE (F).

_____1. The wingsweep sensor is positioned by the wingsweep handle.

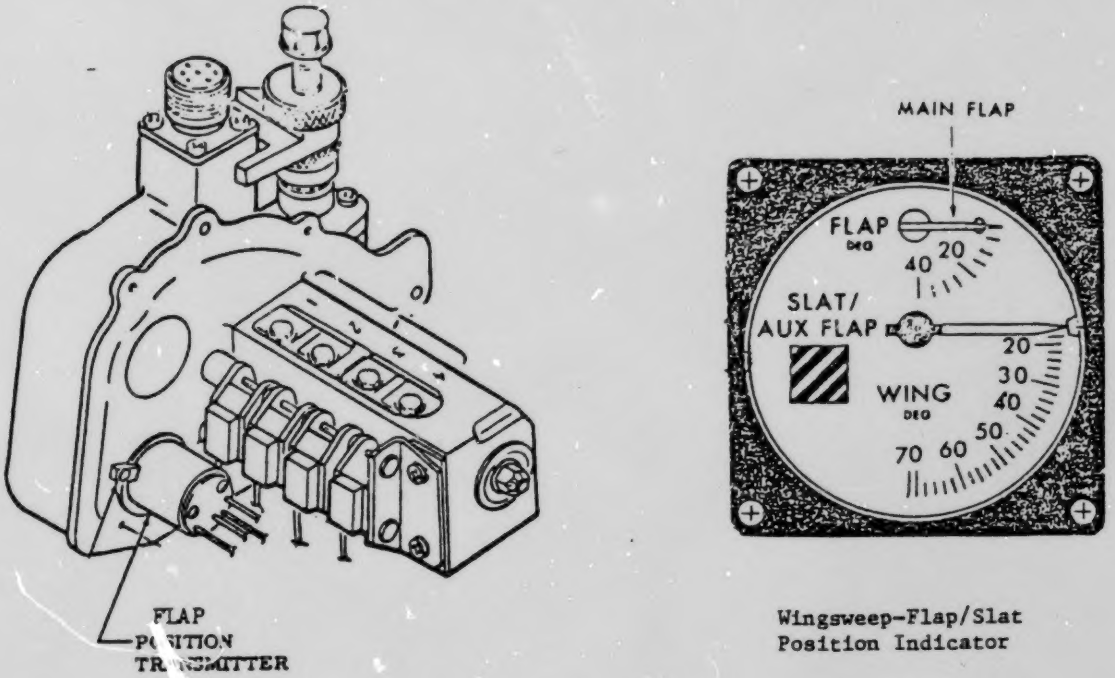
_____2. The actual wingsweep pointer follows the wingsweep angle.

Answers to Frame 6: 1. b

465

Frame 8

The second section of the wingsweep-flap/slat position indicating system is the flap position section. The flap position transmitter is located under a cover on the flap/slat main drive actuator and is a remote synchro transmitter. The flap position is displayed on the wingsweep flap/slat position indicator by a pointer on a scale graduated from 0° to 40° down and operates by a receiver synchro located in the indicator. See figure 5 below.



Flap/Slat Main Drive Actuator

Wingsweep-Flap/Slat Position Indicator

Figure 5.

Mark the following statements as TRUE (T) or FALSE (F).

_____1. The flap position transmitter is located on the flap/slat main drive actuator.

_____2. The main flap position display on the wingsweep-flap/slat position indicator is synchro operated.

_____3. The flap position scale is graduated from 0° to 40° down.

Answers to Frame 7: __F__1. __T__2.

487

Refer to figure 2 of Handout 3ABR32632B-HO-302 while reading this frame.

When the pilot places the flap/slat handle to the flap down position a hydraulic control valve is opened and thus the main flaps begin to extend from the trailing edge of the wing. As the flaps begin to move the rotor of the flap position transmitter is turned. When the flap position transmitter rotor is turned, a voltage is induced through the transmitter stators to the stators of the flap position receiver in the wingsweep-flap/slat position indicator. The induced voltage of the stators creates a magnetic field which turns the rotor of receiver synchro. This rotor then positions the pointer to a position corresponding to the degrees of extension in which the flaps have been placed.

NO RESPONSE REQUIRED

Answers to Frame 8: _T_ 1. _T_ 2. _T_ 3.

467

Frame 10

Thus far, we have dealt only with the remote synchro indicating portions of the wingsweep-flap/slat position indicating system. In the following frames we will cover the magnetic solenoid operated slat and auxiliary flap display.

NO RESPONSE REQUIRED

Answers to Frame 9: NO RESPONSE REQUIRED

The position of the slats and the auxiliary flaps is displayed by a four position solenoid operated semicircular device. The four positions are shown in figure 6 below. The four positions are: "UP," when the slats and the auxiliary flaps are streamlines (inside the wing), "BOTH DOWN," when the slats and auxiliary flaps are fully extended, "SLAT DOWN," when only the slats are extended, and "CROSSHATCH," whenever the surfaces are moving or when power has been lost to the system.

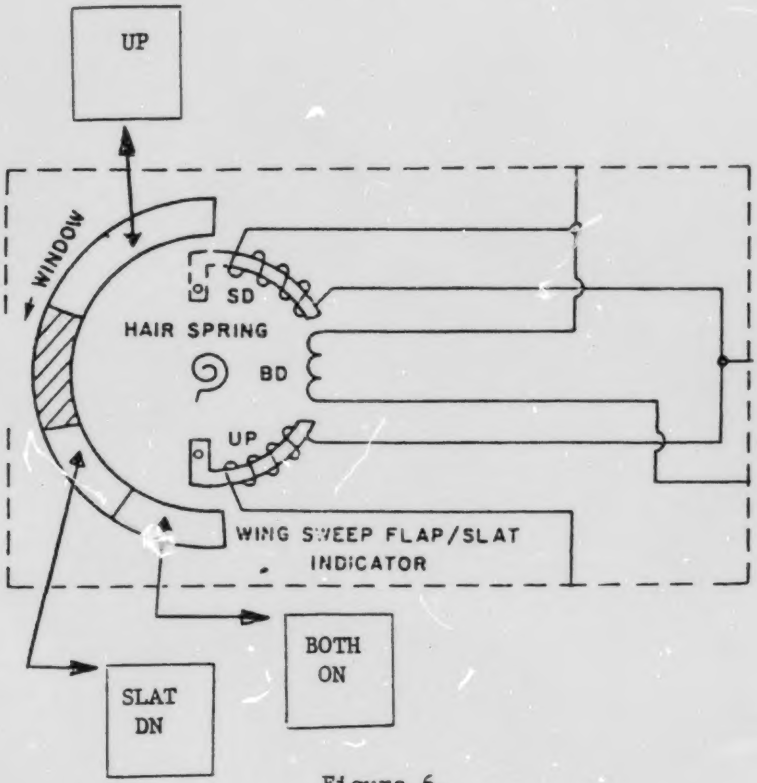


Figure 6.

Circle the letter of the correct response to the following statements.

1. A CROSSHATCH indication means that
   a. power has been lost from the system.
   b. the surfaces are moving or power has been lost from the system.
   c. the surfaces are moving or transmitter failure.

2. The "UP" and "BOTH DOWN" indications refers to the
   a. spoilers and main flap positions.
   b. slats and wingsweep positions.
   c. slats and auxiliary flap positions.

Answers to Frame 10: NO RESPONSE REQUIRED

Frame 12

Refer to figure 3 of Handout 3ABR32632B-HO-302 while reading frames 12 through 15.

The "CROSSHATCH" design will appear in the slat/auxiliary flap window of the wingsweep-flap/slat position indicator whenever power is lost from the system and also whenever the surfaces are moving. Look at figure 3. When the circuit breaker CB-1 is open, no power is applied to any of the three coils in the wingsweep-flap/slat position indicator. Notice that there is a hairspring attached to the indicator drum. This hairspring is attached in a way to make the "CROSSHATCH" indication the neutral (center) position of the drum With this type of set up, whenever power is lost the indicating drum will be rotated to the "CROSSHATCH" indication by the hairspring tension.

Now, let's engage (close) CB-1. Power is applied to the system and depending on the position of the mechanical switches, the "CROSSHATCH" will be removed from the window. If the surfaces are moving, the mechanical switches are also moving between contact points. In effect, power has been removed from the coils and the "CROSSHATCH" will appear in the window.

Mark the following statements as TRUE (T) or FALSE (F).

_____1. The hairspring is neutral when the indicator is "BOTH DOWN."

_____2. When the surfaces are moving, no mechanical switches are closed.

_____3. With the circuit breaker, CB-1 open, the "CROSSHATCH" will appear.

Answers to Frame 11: 1. b 2. c

The "UP" indication appears in the indicator window when the slats and aux flaps are streamlined (inside the leading edge of the wing). Let's set up this situation using figure 3 of 3ABR32632B-HO-302. First close CB-1. Now observe the switch labeled "Slat Return Indicator," it is closed when the slats are in the streamlined position (0%). This provides a ground for the Up coil of the indicator. To complete the circuit, locate the top contacts of the aux flap actuator switches. These switches will be in the up position whenever the aux flaps are streamlined. Now trace the circuit from ground to the Up coil, through the closed top contacts of the aux flap actuator switches to CB-1. This allows the Up coil of the indicator to energize and pull the drum counterclockwise to the "UP" display of the indicator.

Using figure 3, circle the letter of the correct response to the following statements.

1. The Up solenoid coil ground is provided by the

   a. aux flap actuator 100% switches.

   b. slat 70% switches.

   c. slat return indicator 0% switch.

2. The indication "UP" will appear when the slats and aux flaps are

   a. moving.

   b. deployed.

   c. inoperative.

   d. streamlined.

Answers to Frame 12: __F__ 1. __T__ 2. __T__ 3.

Frame 14

The pilot can extend the slats without extending the aux flaps. This is possible due to the fact that the slats must be fully extended before the aux flaps begin to extend. When this occurs, the two slat position monitor 70% switches, shown in figure 3 of 3ABR32632B-HO-302, close as the slats reach the 70% extension point. At this time the slat return indicator switch opens. A path to ground is now provided for the slat down solenoid coil in the indicator. Since the aux flaps have not been extended, the aux flap actuator switches will still be in the 0% position. With CB-1 closed, we can trace a complete circuit from the ground at the slat position monitor through the slat down coil to the circuit breaker. Now that the slat down coil has been energized, the indicator drum would be pulled clockwise to the "slat down" position.

Circle the letter of the correct response to the following statements.

1. When the slat down coil is energized, the dial rotates to what position?

   a. 'UP"

   b. "Crosshatch"

   c. "Slat down"

   d. "Both down"

2. With the slats down,

   a. the slat return indicator switch closes.

   b. circuit breaker CB-1 opens.

   c. one slat position monitor switch closes.

   d. both slat position monitor switches close.

Answers to Frame 13: 1. c 2. d

The pilot may also extend both the slats and aux flaps. When this occurs the slats are fully extended before the aux flaps begin to extend. Using figure 3 of 3ABR32632B-HO-302 for this condition, the following will occur. With the slats fully extended, the slat position monitor switches are closed and the aux flap actuator switches are closed to the top contacts. This causes the "slat down" indication to be displayed by the indicator. As the aux flaps begin to extend the aux flap actuator switches open and the indicator will display the "crosshatch" indication until the aux flaps are fully extended. When the aux flaps reach full extension the aux flap actuator switches close to the bottom contacts and complete the circuit for the both down coil. Now trace the circuit from the slat position monitor ground through the both down coil to the bottom contacts of the aux, flap actuator switches and onto the circuit breaker. With the both down coil energized, the indicator will display the "both down" indication.

Mark the following statements as TRUE (T) or FALSE (F).

_____1. The slats will extend fully before the aux flaps begin to move.

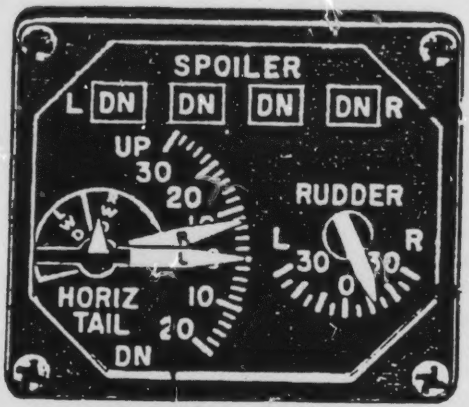
_____2. When the aux flaps are fully extended, the aux flap actuator switches close to the bottom contacts.

_____3. The ground for the both down coil is provided by the slat return indicator switch.

Answers to Frame 14: 1. c 2. d

Frame 16

The wingsweep-flap/slat position indicating system that we have previously discussed displayed the position of the aircraft surfaces that create and maintain lift. The second system we will discuss is the control surface position indicating system. This system is used to provide a visual display of the position of the left and right horizontal stabilizer, rudder, and spoilers. See figure 7 below. These surfaces are used to control the aircraft in pitch, roll, and yaw.



Control Surface Position
Indicator

Figure 7.

Circle the letter of the correct response to the following statements.

1. The control surface position indicating system shows

   a. rudder, wingsweep, and spoiler positions.

   b. horizontal stabilizers, rudder, and spoiler positions.

   c. horizontal stabilizers, rudder, and flap positions.

2. Control surfaces control the aircraft in

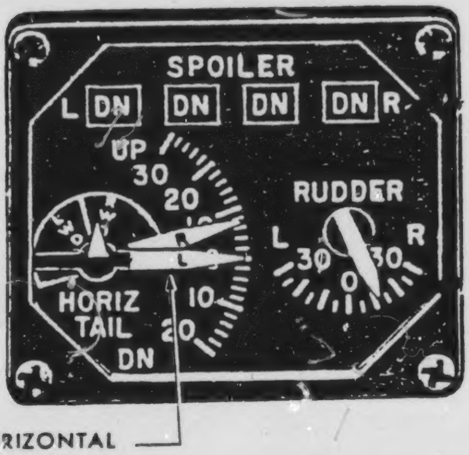
   a. pitch, roll, and lift.

   b. roll, drag, and yaw.

   c. roll, pitch, and yaw.

Answers to Frame 15: T 1. T 2. F 3.

The right and left horizontal stabilizers positions are displayed by two pointers that rotate independently of each other and are referenced against an indicator scale graduated from 20° TED (trailing edge down) to 30° TEU (trailing edge up) in 2° increments. See figure 8a below. When the horizontal stabilizers move in the same direction (symmetrical), the aircraft moves in pitch. As the horizontal stabilizers move in opposite directions (assymmetrical), the aircraft moves in roll. The right pointer has a semicircular disc marked with RWD (right wing down) and LWD (left wing down) attached to the base of it. See figure 8b below. The left pointer has a small triangular pointer attached to its shaft. See figure 8c below. As the pointers are repositioned by the stabilizers, the semicircular disc and the triangular pointer are also repositioned to display the roll condition of the aircraft.



HORIZONTAL STABILIZERS

Figure 8a

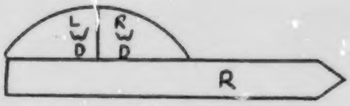


Figure 8b

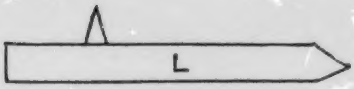


Figure 8c

Mark the following statements as TRUE (T) or FALSE (F).

_____1. The horizontal stabilizer pointers are turned together.

_____2. The horizontal stabilizer scale is graduated from 20° TED to 30° TEU.

_____3. The triangular pointer and semicircular disc display the roll condition of the aircraft.

Answers to Frame 16: 1. b 2. c

Frame 18

The transmitters for the horizontal stabilizers positions are synchro transmitters and are located one on each pivot shaft of the horizontal stabilizers. See figure 9 below.

Use figure 4 of 3ABR32632B-HO-302 and trace the synchro operated signal flow from the horizontal stabilizer synchro transmitters to the horizontal stabilizer pointers in the control surface position indicator.

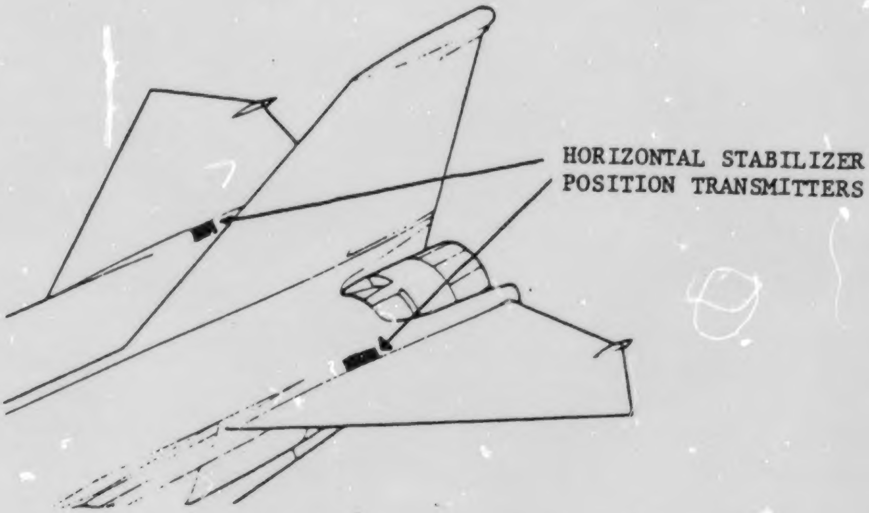


Figure 9.

Circle the letter of the correct response to the following statement.

1. The synchro transmitters for the horizontal stabilizers are located

   a. on the indicator.

   b. on the stabilizers.

   c. on the stabilizer's pivot shafts.

Answers to Frame 17: F 1. T 2. T 3.

Frame 19

The rudder portion of the control surface position indicating system is also a remote synchro system like that of the horizontal stabilizer position system. The rudder transmitter is located on the rudder pivot shaft as shown in figure 10a below. The indicator display for the rudder position is a pointer referenced to a scale graduated from 30° left of center to 30° right of center with 0° as the center position. See figure 10b below.

Using figure 4 of 3ABR32632B-HO-302, trace the rudder signal flow as you did for the horizontal stabilizers.

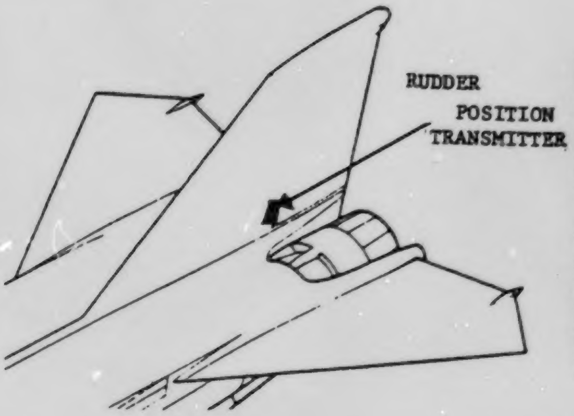

RUDDER
POSITION
TRANSMITTER

Figure 10a.

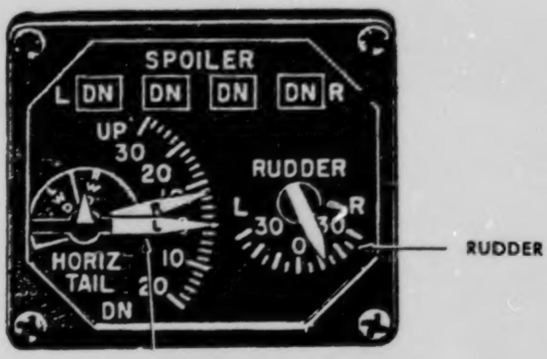

SPOILER
L DN
DN
DN
DN R
UP
30
20
10
HORIZ
TAIL
DN
10
20
RUDDER
L
R
30
0
30
RUDDER

Figure 10b.

Circle the letter of the correct response to the following statement.

1. The rudder position scale is graduated from

   a. 15° left to 15° right of center.

   b. 30° left to 30° right of center.

   c. 0° to 60°.

Answers to Frame 18: 1. c

Frame 20

The last portion of the control surface position indicating system to be discussed is the spoiler section. The indicator display of the spoiler position is a four window display as shown in figure 11a below. There is one window for each spoiler and the display is controlled by four solenoid coils in the indicator. Each window can display one of two indications: Down and Blank. These indications can be seen in figure 11b below.

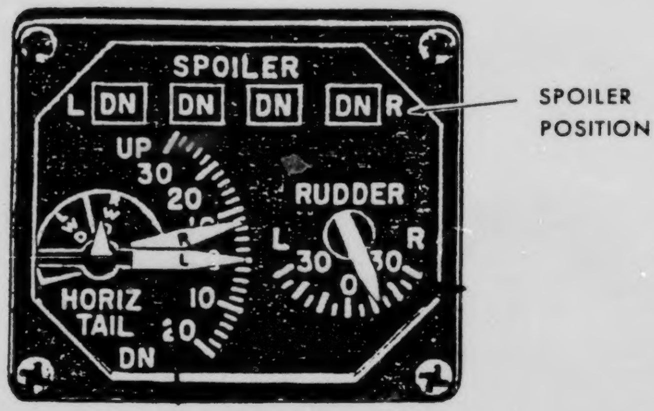

SPOILER
L
DN
DN
DN
DN
R
SPOILER POSITION
UP
30
20
10
RUDDER
L
R
30
0
30
HORIZ
TAIL
10
20
DN

Figure 11a

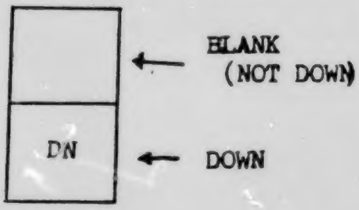

BLANK (NOT DOWN)
DN
DOWN

Figure 11b

Circle the letter of the correct response to the following statements.

1. The control surface position indicator contains how many spoiler windows?

   a. 2.

   b. 3.

   c. 4.

   d. 6.

2. The two positions of the spoiler windows are

   a. Up and Blank.

   b. Up and Down.

   c. Down and Blank.

Answers to Frame 19: 1. b

Each of the four solenoid coils in the control surface position indicator are controlled by a microswitch that is located on the wing where the spoiler makes contact while in the Down position.

Refer to figure 4 of 3ABR32632B-HO-302 for use with the following explanation.

As long as the spoilers are in the Down position, the spoiler retract microswitches are closed. With these microswitches closed, the solenoid coils in the indicator are supplied with a ground and can energize and hold the "Blank" shutter out of view. Whenever the spoilers raise the spoiler retract microswitch will open and remove the ground for the solenoid coils. At this time the solenoid coils deenergize and the "Blank" shutter will be pulled by a hairspring over the "Down" indication.

Circle the letter of the correct response to the following statement.

1. What indication will be displayed in the spoiler windows when the spoiler retract microswitches are closed?

   a. Up.

   b. Down.

   c. Blank.

Answers to Frame 20: 1. c 2. c

Frame 22

Match the components listed in column B to the functions listed in column A by placing the letter of the component in the space provided.

A

_____1. Moved by the wingsweep control handle

_____2. Monitors the angle of wingsweep.

_____3. Repositions the flap position synchro transmitter.

_____4. Indicates two wingsweep positions; main flap and slat/aux flap positions.

_____5. Indicates a power failure to the wingsweep/flap/slat indicator.

_____6. Shows the positions of the rudder, two horizontal stabilizers and spoilers.

_____7. 4 position solenoid display.

_____8. Their position is read on a scale of 30° TEU to 20° TED.

_____9. Repositioned by the rudder pivot shaft.

____10. Pulls a shutter over the DN when the spoilers are up.

B

a. Wingsweep Sensor.

b. Control Surface Position Indicator.

c. "Crosshatch"

d. Horizontal Stabilizers.

e. Desired Wingsweep Transmitter.

f. Rudder Position Transmitter.

g. Hairspring.

h. Flap/Slat Main Drive Actuator.

i. Spoiler Windows.

j. Wingsweep Flap/Slat Indicator.

Answers to Frame 21: 1. b

Answers to Frame 22: __e__1. __a__2. __h__3. __j__4. __c__5.

__b__6. __i__7. __d__8. __f__9. __g__10.

Return to the beginning of the programmed text and review the objective. When you are satisfied that you know and understand the material, you will take an appraisal.

WORKBOOK

3ABR32531-WB-201

Technical Training

Avionics Instrument Systems Specialist

INSPECTION, OPERATIONAL CHECK, TROUBLESHOOTING, AND BENCH CHECK OF POSITION INDICATING SYSTEMS

3 April 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360th Technical Training Group
Chanute Air Force Base, Illinois

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DO NOT USE ON THE JOB.

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-201

INSPECTION, OPERATIONAL CHECK, TROUBLESHOOTING, AND BENCH CHECK OF POSITION INDICATING SYSTEMS

OBJECTIVES

Given a workbook and trainers, perform an inspection and operational check of Position Indicating Systems with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment and trainers, troubleshoot Position Indicating Systems with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainers, bench check Position Indicating Systems with an accuracy of 100% correct workbook responses.

SECTION A

EQUIPMENT

	Basis of Issue
Wheel Position Indicating Trainer	1/2 students
Multimeter	1/2 students
3ABR32531-WB-201	1/student
3ABR32531-HO-201	1/student

6. Using the multimeter, and the schematic on the trainer, locate the trouble indicated. Record the trouble indication in your response booklet.

PROCEDURE

Follow the procedures carefully and make the appropriate responses in your response book. After completing the workbook your instructor will check your responses for accuracy.

CAUTION: **Remove all jewelry before performing the following procedures! Be sure that the trainer is not connected to the 28V DC power supply.**

Place a checkmark (✓) on the proper blank in your response book indicating the condition or proper operation of the unit.

Supersedes 3ABR32531-WB-202 and 3ABR32632B-WB-302, 28 March 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 200; TTVSA - 1

Part 1. INSPECTION AND OPERATIONAL CHECK

Disconnect front and rear connector plugs on trainer.

		SAT.	UNSAT.
1.	Inspect the Wheel Position Indicator for:		
	a. Security of mounting		
	b. Dented or cracked case		
	c. Loose or cracked glass		
	d. Connector plug and pins for damage and corrosion		

		SAT.	UNSAT.
2.	Inspect system wiring for condition:		
	a. Frayed wires		
	b. Broken wires		
	c. Bent or broken pins on connector plugs		
	d. Cracked or broken connector plugs		

		SAT.	UNSAT.
3.	Inspect circuit breaker for:		
	a. Security of mounting		
	b. Cracked case		
	c. Terminals for looseness and corrosion		
	d. Positive action (PUSH, PULL)		

		SAT.	UNSAT.
4.	Inspect microswitches for:		
	a. Security of mounting		
	b. Loose terminals		
	c. Cracked or broken switch case		

5. Reconnect front and rear connector plugs.

Note: Make sure keyways are aligned. Tighten plug finger tight.

6. Make sure all trouble switches on the side of the trainer are to the "OUT" position. Make sure circuit breaker is pulled.

7. Connect trainer to 28V DC power outlet and begin operational check.

    a. Push circuit breaker in.

8. Hold the landing gear in the DOWN position so that the microswitch is closed. Indicator indicates DOWN and locked. SAT. ____ UNSAT. ____

9. Place landing gear in the UNSAFE position. The indicator indicates UNSAFE. ____ ____

10. Hold landing gear in the UP position. The indicator indicates UP. ____ ____

Part 2. TROUBLESHOOTING

Place a checkmark (✓) beside the indicated readings and circle the number of the most probable location of the malfunction of the Trouble Switches #1 and #2.

1. Place trouble switch #1 to the IN position.

    a. Hold the landing gear to the DOWN and locked position to activate the DOWN microswitch. SAT. UNSAT.

    The indicator indicates (DOWN and LOCKED___), (UNSAFE___), (UP and LOCKED___). ____ ____

    b. Place the landing gear to the UNSAFE position.

    The indicator indicates (DOWN and LOCKED___), (UNSAFE___), (UP and LOCKED___). ____ ____

    c. Hold the landing gear to the UP and LOCKED position to activate the UP microswitch.

    The indicator indicates (DOWN and LOCKED___), (UNSAFE___), (UP and LOCKED___). ____ ____

    d. The most probable location of the malfunction is:

        (1) Between the UP and LOCKED microswitch and the DOWN coil of the indicator ______.

        (2) Between the DOWN and LOCKED microswitch and the DOWN coil of the indicator ______.

        (3) Between the UP and LOCKED microswitch and the UP coil of the indicator ______.

2. Place trouble switch #1 to the OUT position and trouble switch #2 to the IN position.

   a. Hold the landing gear to the DOWN and LOCKED position to activate the DOWN microswitch. SAT. UNSAT.

      The indicator indicates (DOWN and LOCKED___), (UNSAFE___), (UP and LOCKED___). _____ _____

   b. Place the landing gear to the UNSAFE position.

      The indicator indicates (DOWN and LOCKED___), (UNSAFE___), (UP and LOCKED___). _____ _____

   c. Hold the landing gear to the UP and LOCKED position to activate the UP microswitch.

      The indicator indicates (DOWN and LOCKED___), (UNSAFE___), (UP and LOCKED___). _____ _____

   d. The most probable location of the malfunction is:

      (1) Between the DOWN and LOCKED switch and the circuit breaker ______.

      (2) Between the UP and LOCKED switch and the UP coil of the indicator ______.

      (3) Between the UP and LOCKED switch and the DOWN coil of the indicator ______.

   CAUTION: PULL CIRCUIT BREAKER AND DISCONNECT TRAINER POWER PLUG FROM OUTLET.

3. Prepare the multimeter for troubleshooting.

   a. Connect red lead to the red receptacle and the black lead to the black receptacle.

   b. Place FUNCTION switch to OHMS.

   c. Place RANGE switch to the OHMS X 1 position.

   d. Short the red and black leads together and zero the meter with the OHMS ZERO ADJUST KNOB.

4. Disconnect the front and rear connector plugs from the trainer.

5. Place trouble switch #2 to the OUT position and #1 to the IN position.

6. Using the multimeter, and the schematic on the trainer, locate the trouble indicated. Record the trouble indication in your response booklet.

485

NOTE: TROUBLE WILL NOT BE FOUND BETWEEN MICROSWITCH AND THE FEMALE CONNECTOR AT THE REAR OF THE TRAINER!

7. Record the location of the trouble by circling the letter of the correct statement.
   - a. Open D77A20N.
   - b. D113B20 Open.
   - c. Open "A" between female indicator connector and test point A.
   - d. Open "C" between female indicator connector and test point C.
8. Place #1 trouble switch to the out position, and place #2 trouble switch to the in position.
9. Record the location of the trouble by circling the letter of the correct statement.
   - a. Open D114B20.
   - b. Crossed A & C leads at indicator connector.
   - c. Crossed B & C leads at indicator connector.
10. Place #2 trouble switch to out position.

Part 3. BENCH CHECK

1. Reconnect the front connector plug.
2. Using the multimeter, measure the resistance of the indicator coils at the indicator test points A, B, C,. Record these resistance values in the proper blanks and place a checkmark (✓) in your response booklet to indicate whether the value is Satisfactory or Unsatisfactory.
3. Place multimeter range switch on OHMS X 100.

	OHMS	SAT	UNSAT
a. Test point A to test point B (1050 ohms ± 20%)	____	____	____
b. Test point B to test point C (1050 ohms ± 20%)	____	____	____
c. Test point A to test point C (2200 ohms ± 20%)	____	____	____

4. Reconnect rear connector plug on trainer finger tight. (Make sure KEYWAY is aligned.)
5. Place multimeter FUNCTION switch to DC VOLTS and the RANGE switch to 1000. (Safety L position).
6. Disconnect leads from multimeter.
7. Place multimeter and leads back into the meter cabinet.

8. Place trainer back on proper shelf.

9. Have instructor check your workbook.

SECTION B

EQUIPMENT

	Basis of Issue
Flap Position Indicator Trainer	1/2 students
Multimeter	1/2 students
3ABR32531-WB-201	1/student
3ABR32531-HO-201	1/student

PROCEDURE

Remove all jewelry.

Be sure the trainer is not connected to the power source. Disconnect the connector plugs at the indicator and transmitter. Pull circuit breaker on trainer.

NOTE: OBTAIN ALL EQUIPMENT BEFORE STARTING LAB/PROJECT. Place a checkmark (✓) in your response book indicating the condition or proper operation of the unit.

Part 1. INSPECTION AND OPERATIONAL CHECK

	SAT.	UNSAT.
1. Inspect the Flap Position Indicator for:		
a. Security of mounting	____	____
b. Loose or cracked glass	____	____
c. Condition of dial and pointer	____	____
d. Dented or cracked case	____	____
e. Connector plug and pins for damage or corrosion	____	____
2. Inspect the Flap Position Transmitter for:	SAT.	UNSAT.
a. Security of mounting	____	____
b. Dented or cracked case	____	____
c. Connector plug pins for damage or corrosion	____	____
3. Inspect the circuit breaker for:	SAT.	UNSAT.
a. Security of mounting	____	____
b. Dented or cracked case	____	____

c. Terminals for looseness and corrosion ____ ____

d. Positive action (push-pull) ____ ____

4. Inspect system wiring for: SAT. UNSAT.

a. Frayed wires ____ ____

b. Broken wires ____ ____

c. Cracked or broken connector plugs (2 each) ____ ____

5. Reconnect front and rear connector plugs on trainer.

6. Connect trainer to 28V DC outlet and begin operational check.

Caution: Make sure all trouble switches are to the OUT position.

7. Place flap to UP position.

a. Indicator indicates (flap up___), (flap down___), (flap offscale up___), (flap 15°___).

b. Push circuit breaker in. Indicator indicates (flap up___), (flap down___), (flap offscale up___), (flap 15°___).

8. Place flap to 15° mark on trainer.

a. Indicator indicates (flap up___), (flap down___), (flap offscale up___), (flap 15°___).

b. Pull circuit breaker. Indicator indicates (flap up___), (flap down___), (flap offscale up___), (flap 15°___).

c. Reset circuit breaker. Indicator indicates (flap up___), (flap down___), (flap offscale up___), (flap 15°___).

9. Place flap to DOWN position.

a. Indicator indicates (flap up___), (flap down___), (flap offscale up___), (flap 15°___).

b. Pull circuit breaker. Indicator indicates (flap up___), (flap down___), (flap offscale up___), (flap 15°___).

c. Reset circuit breaker. Indicator indicates (flap up___), (flap down___), (flap offscale up___), (flap 15°___).

10. Place flap to UP position and pull circuit breaker.

Part 2. TROUBLESHOOTING

1. Prepare the system for troubleshooting as follows:

   a. Insure that the circuit breaker is pulled out.

   b. Insure that wing flap is in the UP position.

   c. Insure that all trouble switches are to the OUT position.

   d. Push in circuit breaker.

2. Place trouble switch #1 to the IN position.

   a. Place flap in UP position.

      Indicator indicates

   b. Place flap to 15° mark on trainer.

      Indicator indicates

   c. Place flap to DOWN position.

      Indicator indicates

3. Place trouble switch #1 to the OUT position and switch #2 to the IN position.

   a. Place flap in UP position.

      Indicator indicates

   b. Place flap to 15° mark on trainer.

      Indicator indicates

   c. Place flap to DOWN position.

      Indicator indicates
      up___), (flap 15°___).

4. Place trouble switch #2 to the OUT position and switch #3 to the IN position.

a. Place flap in UP position.

Indicator indicates

b. Place flap to 15° mark on trainer.

Indicator indicates

c. Place flap to DOWN position.

Indicator indicates

5. Place trouble switch #3 to the OUT position and switch #4 to the IN position.

a. Place flap in UP position.

Indicator indicates

b. Place flap to 15° mark on trainer.

Indicator indicates

c. Place flap in DOWN position.

Indicator indicates

6. Place trouble switch #4 to the OUT position and switch #5 to the IN position.

a. Place flap in UP position.

Indicator indicates

b. Place flap to 15° mark on trainer.

Indicator indicates

c. Place flap in DOWN position.

Indicator indicates

7. Place trouble switch #5 to the OUT position and switch #6 to the IN position.

   a. Place flap in UP position.

      Indicator indicates

   b. Place flap to 15° mark on trainer.

      Indicator indicates

   c. Place flap in DOWN position.

      Indicator indicates

8. Place switch #6 to the OUT position.

   PULL CIRCUIT BREAKER AND DISCONNECT TRAINER PLUG FROM OUTLET.

   DISCONNECT FRONT AND REAR CONNECTOR PLUGS ON TRAINER.

9. Obtain a multimeter and a red and black lead from the meter cabinet. Connect the red lead to the red receptacle and the black lead to the black receptacle.

   a. Place Function switch to OHMS.

   b. Place Range switch to OHMS X1.

   c. Short the red and black leads together and zero the meter using the OHMS ZERO ADJUST KNOB.

10. Using the multimeter and the schematic provided on the trainer, locate and record the trouble indicated.

    Note: Use TEST POINTS on trainer ONLY.

    EXAMPLE: #D7A20 OPEN, SHORT OR CROSSED WIRES.

    a. Place trouble switch #1 to the IN position.

    WIRE # ____________________ CAUSE ______________________

    b. Place trouble switch #1 to the OUT position and trouble switch #2 to the IN position.

    WIRE # ____________________ CAUSE ______________________

c. Place trouble switch #2 to the OUT position and trouble switch #3 to the IN position.

WIRE # ____________________ CAUSE ____________________

d. Place trouble switch #3 to the OUT position and trouble switch #4 to the IN position.

WIRE # ____________________ CAUSE ____________________

e. Place trouble switch #4 to the OUT position and trouble switch #5 to the IN position.

WIRE # ____________________ CAUSE ____________________

f. Place trouble switch #5 to the OUT position and trouble switch #6 to the IN position.

WIRE # ____________________ CAUSE ____________________

g. Place trouble switch #6 to the OUT position.

11. Have instructor check your workbook.

Part 3. BENCH CHECK

1. Reconnect the front connector plug to indicator.

CAUTION: Make sure trainer plug is disconnected from 28V DC and all trouble switches are to the OUT position.

2. Using the multimeter, perform a resistance check on the indicator and transmitter IAW the instructions below. Record these resistance values in the proper blanks in your response booklet and place a (✓) to indicate whether the value is Satisfactory or Unsatisfactory.

3. Check the resistance of the indicator coils at the indicator test points A, B and C with ohmmeter on X10 range.

Note: The resistance values should be the same for each measurement.

	OHMS	SAT	UNSAT
a. Test Point A to Test Point B	____	____	____
b. Test Point A to Test Point C	____	____	____
c. Test Point B to Test Point C	____	____	____

4. Disconnect front connector plug and connect rear connector plug to transmitter.

5. Check resistance of the transmitter at the transmitter test points A, B, C.

	OHMS	SAT	UNSAT
a. Test Point A to Test Point B			
b. Test Point A to Test Point C			
c. Test Point B to Test Point C			

6. Reconnect front connector plug on trainer.

7. Place FUNCTION switch on the multimeter to DC VOLTS and RANGE switch to 1000. (Safety L position)

8. Disconnect leads from the multimeter. Return multimeter and leads to meter cabinet. Erase your name on the signout board.

9. Return trainer to proper shelf.

HANDOUT

3ABR32531-HO-200A

Technical Training

Avionics Instrument Systems Specialist

ENGINE INSTRUMENTS
(WORKBOOK RESPONSE BOOKLET)

7 May 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

494

ENGINE INSTRUMENTS (WORKBOOK RESPONSE BOOKLET)

This booklet contains handouts 3ABR32531-HO-201 through -209. Each handout is to be used to record your responses to items in the workbook carrying the same number. Each blank in this response booklet will have a corresponding blank in the workbook.

Record your answers in this book. DO NOT WRITE IN THE WORKBOOK.

CONTENTS

UNIT	TITLE	PAGE
201	Position Indicating Systems	3
202	Pressure Indicating Systems	6
203	Tachometer Systems	12
204	Temperature Indicating Systems	15
205	Fuel Flow Indicating System	19
206	Engine Pressure Ratio System	21
207	Resistance-Type Liquid Quantity System	23
208	Capacitance Liquid Quantity System	24
209	Vertical Scale Engine Instruments	26

Supersedes 3ABR32531-WB-203 (Response Booklet), 26 December 1978, which may be used until existing stocks are exhausted.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 400; TTVSA - 1

UNIT 201
POSITION INDICATING SYSTEMS
Section A. WHEEL POSITION

Part I. INSPECTION AND OPERATIONAL CHECK

INSPECTION

	SAT	UNSAT		SAT	UNSAT		SAT	UNSAT		SAT	UNSAT
1.a	____	____	2.a	____	____	3.a	____	____	4.a	____	____
b	____	____	b	____	____	b	____	____	b	____	____
c	____	____	c	____	____	c	____	____	c	____	____
d	____	____	d	____	____	d	____	____	d	____	____

OPERATIONAL CHECK

	SAT	UNSAT		SAT	UNSAT		SAT	UNSAT
8. Down	____	____	9. Unsafe	____	____	10. Up	____	____

Part II. TROUBLESHOOTING

		SAT	UNSAT
1. Sw #1 to IN position (Indicator Indicates)			
a. Down and locked	______________________	____	____
b. Unsafe	______________________	____	____
c. Up and locked	______________________	____	____

d. Most probable location of malfunction (Use ✓ Check Mark)

(1) _____.
(2) _____.
(3) _____.

		SAT	UNSAT
2. Sw #2 to IN position (Indicator Indicates)			
a. Down and locked	______________________	____	____
b. Unsafe	______________________	____	____
c. Up and locked	______________________	____	____

d. Most probable location of malfunction (Use ✓ Check Mark)

(1) _____.
(2) _____.
(3) _____.

Record the location of the trouble by circling the letter of the correct statement.

7. Sw #1 to IN Position
   - a.
   - b.
   - c.
   - d.

9. Sw #2 to IN Position
   - a.
   - b.
   - c.

Part III. BENCH CHECK

3. Measure resistance of indicator coils	OHMS	SAT	UNSAT
a. A to B	____	____	____
b. B to C	____	____	____
c. A to C	____	____	____

Section B. FLAP POSITION

Part I. INSPECTION AND OPERATIONAL CHECK

INSPECTION

	SAT	UNSAT		SAT	UNSAT		SAT	UNSAT		SAT	UNSAT
1.a	____	____	2.a	____	____	3.a	____	____	4.a	____	____
b	____	____	b	____	____	b	____	____	b	____	____
c	____	____	c	____	____	c	____	____	c	____	____
d	____	____				d	____	____			
e	____	____									

OPERATIONAL CHECK

7. Flap UP (Indicator Indicates)
a. ____________________
b. Push CB ____________________

8. Flap to 15° (Indicator Indicates)
a. ____________________
b. Pull CB ____________________
c. Reset CB ____________________

9. Flap DOWN
a. ____________
b. Pull CB ____________
c. Reset CB ____________

Part II. TROUBLESHOOTING

(Indicator Indicates)

2. Sw #1 to IN Position
a. Flap Up ____________
b. Flap 15° ____________
c. Flap DOWN ____________

(Indicator Indicates)

3. Sw #2 to IN Position
a. Flap UP ____________
b. Flap to 15° ____________
c. Flap DOWN ____________

4. Sw #3 to IN Position

   a. Flap UP ________
   b. Flap 15° ________
   c. Flap DOWN ________

5. Sw #4 to IN Position

   a. Flap UP ________
   b. Flap 15° ________
   c. Flap DOWN ________

6. Sw #5 to IN Position

   a. Flap UP ________
   b. Flap 15° ________
   c. Flap DOWN ________

7. Sw #6 to IN Position

   a. Flap UP ________
   b. Flap 15° ________
   c. Flap DOWN ________

10. Locate and record the indicated trouble

    a. Sw #1 to IN Position

       Wire # ________ Cause ________

    b. Sw #2 to IN Position

       Wire # ________ Cause ________

    c. Sw #3 to IN Position

       Wire # ________ Cause ________

    d. Sw #4 to IN Position

       Wire # ________ Cause ________

    e. Sw #5 to IN Position

       Wire # ________ Cause ________

    f. Sw #6 to IN Position

       Wire # ________ Cause ________

Part III. BENCH CHECK

	OHMS	SAT	UNSAT
3. Check resistance of indicator coils			
a. A to B	____	____	____
b. A to C	____	____	____
c. B to C	____	____	____
5. Check resistance of transmitter coils			
a. A to B	____	____	____
b. A to C	____	____	____
c. B to C	____	____	____

UNIT 202
PRESSURE INDICATING SYSTEMS
Section A. DIRECT PRESSURE

INSPECTION

	SATISFACTORY	UNSATISFACTORY
1.	________	________
2.	________	________
3.	________	________
4.	________	________
5.	________	________
6.	________	________
7.	________	________
8.	________	________
9.	________	________

____

____

____

OPERATIONAL CHECK

9. Indication is SATISFACTORY _____, UNSATISFACTORY _____

11. Indication is SATISFACTORY _____, UNSATISFACTORY _____

BENCH CHECK

FRICTION AND SCALE ERROR CHART

TEST WEIGHTS	Friction Error BEFORE TAP	Friction Error AFTER TAP	S	U	Scale Error	S	U
0 PSI					0 ± 3 PSI		
50 PSI					50 ± 3 PSI		
100 PSI					100 ± 5 PSI		
150 PSI					150 ± 5 PSI		
200 PSI					200 ± 5 PSI		

TROUBLE FOUND:

1. ____________________

2. ____________________

POSSIBLE CAUSES OF TROUBLE

1. ____________________

2. ____________________

3. ____________________

Section B. SYNCHRO PRESSURE

INSPECTION

	SATISFACTORY	UNSATISFACTORY
1a.		
b.		
c.		
d.		
e.		
f.		
2a.		
b.		
c.		
d.		
3a.		
b.		
c.		
d.		

OPERATIONAL CHECK

	PSI	SATISFACTORY	UNSATISFACTORY
4. 0 psi check	____	____________	______________
5. 50 psi check	____	____________	______________
6. 100 psi check	____	____________	______________
7. 150 psi check	____	____________	______________
8. 200 psi check	____	____________	______________

TROUBLESHOOTING

2. The oil pressure reading is: HIGH ___, LOW ___, ERRATIC ___,

(INOPERATIVE) LAST INDICATION _____.

5. The oil pressure reading is: HIGH ___, LOW ___, ERRATIC ___,

(INOPERATIVE) LAST INDICATION _____.

11a. The location of the trouble is wire number ________________________

b. The trouble is a SHORT ___, OPEN ___, CROSSED WIRES ___.

12a. The location of the trouble is wire number ________________________

b. The trouble is a SHORT ___, OPEN ___, CROSSED WIRES ___.

BENCH CHECK

2a.

(1) TEST POINTS A-D OHMS _____

(2) TEST POINTS D-C OHMS _____

(3) TEST POINTS A-C OHMS _____

b.

(1) TEST POINTS A-B OHMS _____

c. The transmitter is SATISFACTORY _____, UNSATISFACTORY _____

5a.

(2) ACTUAL READING _____________

(3) ACTUAL READING _____________

(4) Power supply voltages are SATISFACTORY ____ UNSATISFACTORY ___

Pressure PSI	°ARC	Tolerance °ARC	Friction Error S	Friction Error U	Before Tap	After Tap	Scale Error S	Scale Error U
0	20	4.8°						
50	100	4.8°						
EZ 100	180	6.4°						
150	260	6.4°						
200	340	6.4°						

d. The transmitter is SATISFACTORY _____, UNSATISFACTORY _____

11a. Indicator reads _____ psi.

b. EZ is SATISFACTORY _____, UNSATISFACTORY _____.

Indicator PSI	Test Trans. Reading Degrees	Before Tap PSI	After Tap PSI	Exact Degrees	Friction Error S	Friction Error U	Scale Error S	Scale Error U
0	20°							
50	100°							
100EZ	180°							
150	260°							
200	340°							

a. Friction and scale error tests are SATISFACTORY ____ UNSATISFACTORY ____

14a. Position error check is SATISFACTORY ____ UNSATISFACTORY ____

b. The oil pressure indicator is SATISFACTORY _____ UNSATISFACTORY _____

Section C. VARIABLE RELUCTANCE PRESSURE

INSPECTION

	SATISFACTORY	UNSATISFACTORY
1a.	__________	__________
b.	__________	__________
c.	__________	__________
d.	__________	__________
e.	__________	__________
f.	__________	__________

	SATISFACTORY	UNSATISFACTORY
2a.	__________	__________
b.	__________	__________
c.	__________	__________
d.	__________	__________

OPERATIONAL CHECK

3a. The oil pressure reads OFF SCALE LOW ___, ZERO ___, OFF SCALE HIGH ___.

4a. The oil pressure reads OFF SCALE LOW ___, ZERO ___, OFF SCALE HIGH ___.

6a. The indicator reads ZERO _____, 100 psi _____.

TROUBLESHOOTING

2a. The indicator indicates 60 psi ___, OFF SCALE LOW ___, OFF SCALE HIGH ___.

b. The system is SATISFACTORY _____, UNSATISFACTORY _____.

3a. The indicator indicates 60 psi ___, OFF SCALE LOW ___, OFF SCALE HIGH ___.

b. The system is SATISFACTORY _____, UNSATISFACTORY _____.

4a. The indicator indicates 60 psi ___, OFF SCALE LOW ___, OFF SCALE HIGH ___.

b. The system is SATISFACTORY _____, UNSATISFACTORY _____.

10.

TROUBLE SWITCH	KIND OF TROUBLE	WIRE NUMBER
#1	______________	____________________
#2	______________	____________________
#3	______________	____________________

BENCH CHECK

3a. The indicator indicates _____ psi.

b. The system is SATISFACTORY _____, UNSATISFACTORY _____.

4a. The indicator indicates _____ psi.

b. The system is SATISFACTORY _____, UNSATISFACTORY _____.

5a. The indicator indicates _____ psi.

b. The system is SATISFACTORY _____, UNSATISFACTORY _____.

UNIT 203
TACHOMETER SYSTEMS

Part I. INSPECTION

	SAT	UNSAT
1.a	_____	_____
b	_____	_____
c	_____	_____
d	_____	_____
e	_____	_____
2.a	_____	_____
b	_____	_____
c	_____	_____
d	_____	_____
e	_____	_____

Part II. OPERATIONAL CHECK

2.	PHASE	Voltage	SAT	UNSAT
	A - B	_______	___	_____
	A - C	_______	___	_____
	B - C	_______	___	_____
3.	A - B	_______	___	_____
	A - C	_______	___	_____
	B - C	_______	___	_____

Part III

6.a increase _____ decrease _____ no change _____
b satisfactory _____ unsatisfactory _____

9.a increase _____ decrease _____ no change _____
b satisfactory _____ unsatisfactory _____

14. a
b
c
d

Part IV

1.	PHASE	OHMS	SAT	UNSAT
	A - B	____	_____	____
	A - C	____	_____	____
	B - C	____	_____	____

SCALE ERROR TEST

Gen. Freq. RPM (CPM)	Ind. Reading Percent RPM	Indicator Reading	Tolerance Percent RPM	SAT	UNSAT
0	0		0.50		
200	4.8		0.50		
400	9.5		0.50		
800	19.1		0.50		
1600	38.1		0.80		
2400	57.1		0.80		
3400	81.0		0.50		
3600	85.7		0.50		
3800	90.5		0.50		
4000	95.2		0.50		
4200	100.0		0.50		

2d. Indicator scale error is SAT ____ UNSAT ____.

FRICTION ERROR TEST

Ind. Reading Percent RPM	Allowable Friction Percent RPM	Before Tap	After Tap	SAT	UNSAT
5	1.5				
20	0.8				
40	0.5				
70	0.3				
85	0.3				
100	0.3				

3a. The indicator friction error test is SAT ____, UNSAT _____.

OSCILLATION TEST

Indicator Reading	Oscillation	SAT	UNSAT
Up to 20 percent RPM	0.5 percent RPM		
20 to 110 percent RPM	0.3 percent RPM		

4a. The indicator oscillation test is SAT ___, UNSAT ___.

506

POSITION ERROR TEST

Indicator Reading at 100%	Tolerance	SAT	UNSAT
15° UP	0.30		
15° to the right	0.30		
15° to the left	0.30		
15° DOWN	0.30		

5.b. The indicator position error test is SAT _____, UNSAT _____.

6.a ____________ RPM

b Starting test is SAT _____, UNSAT _____

528

UNIT 204
TEMPERATURE INDICATING SYSTEMS
Section A. RESISTANCE THERMOMETERS

Part I. INSPECTION

1. Resistance thermometer indicator

	SAT	UNSAT
a.	____	____
b.	____	____
c.	____	____
d.	____	____

2. Temperature bulb

	SAT	UNSAT
a.	____	____
b.	____	____

3. Condition of wiring

a.	____	____
b.	____	____
c.	____	____

4. Circuit breaker

a.	____	____
b.	____	____
c.	____	____

Part II. OPERATIONAL CHECK

1d. Off scale cold___, room temperature___, off scale hot____.
1f. Off scale cold___, room temperature___, off scale hot____.
1h. Satisfactory ___, Unsatisfactory ___.
1i.(1) Increase ___, decrease ___, remains the same___.
1j.(1) Increase ___, decrease ___, remains the same___.

Part III. TROUBLESHOOTING

	Off Scale Cold	Room Temperature	Off Scale Hot
1.	#1 switch to IN position		
	a. _____	_____	_____
2.	#2 switch to IN position		
	a. _____	_____	_____
3.	#3 switch to IN position		
	a. _____	_____	_____
4.	#4 switch to IN position		
	a. _____	_____	_____
5.	#5 switch to IN position		
	a. _____	_____	_____
6.	#6 switch to IN position		
	a. _____	_____	_____

12. #1 switch IN
13. Wire # _________.
14. Short _____, Open _____, Crossed wires _____.

15. #2 switch IN
16. Wire # ___________.
17. Short _____, Open _____, Crossed wires _____.

18. #3 switch IN
19. Wire # __________.
20. Short _____, Open _____, Crossed wires _____.

21. #4 switch IN
22. Wire # __________.
23. Short _____, Open _____, Crossed wires _____.

24. #5 switch IN
25. Wire # __________.
26. Short ______, Open _____, Crossed wires _____.

27. #6 switch IN
28. Wire # __________.
29. Short _____, Open _____, Crossed wires _____.

Part IV. BENCH CHECK 28.5 VDC

5.

ACTUAL INDICATION	SAT	UNSAT
_________________	____	____
_________________	____	____
_________________	____	____
_________________	____	____
_________________	____	____
_________________	____	____
_________________	____	____

8. BENCH CHECK 22.5 VDC

_________________	____	____
_________________	____	____
_________________	____	____
_________________	____	____
_________________	____	____
_________________	____	____
_________________	____	____

BENCH CHECK OF THE RESISTANCE BULB

5. Ambient temperature is ___________ degrees centigrade.

6. The calculated resistance is _____________ Ohms.

15. The measured resistance of the bulb is ______________Ohms.

Section B. THERMOCOUPLE THERMOMETERS

Part I. INSPECTION

1. EGT Indicator

	SAT	UNSAT
a.	_____	_____
b.	_____	_____
c.	_____	_____
d.	_____	_____

2. Condition of Wiring

	SAT	UNSAT
a.	_____	_____
b.	_____	_____
c.	_____	_____

3.. Wiring harness and thermocouples for condition

a.	_____	_____
b.	_____	_____
c.	_____	_____
d.	_____	_____

Part II. OPERATIONAL CHECK

2. Heat Rise Check

b. Sat _____ Unsat _____

4. System Operation

b. Sat _____ Unsat _____

Part III. TROUBLESHOOTING

	HIGH	LOW	AMBIENT TEMPERATURE
1. Switch #1 to IN position	_____	_____	_____
2. Switch #2 to IN position	_____	_____	_____
3. Switch #3 to IN position	_____	_____	_____

16. Pos wire ___ Ohms. Neg wire ___Ohms. Pos to neg _____ Ohms.

Circle correct response and record Ohms value for that trouble ONLY.

17. Switch #1 to IN position

a. _______ Ohms
b. _______ Ohms
c. _______ Ohms

18. Switch #2 to IN position

a. ________Ohms
b. ________Ohms
c. ________Ohms

19. Switch #3 to IN position

a. _______ Ohms
b. _______ Ohms
c. _______ Ohms

Part IV. BENCH CHECK

4b. Scale Error Test

Test Point

Switch #2	4b. After Tap	SAT	UNSAT
200°C			
400°C			
500°C			
600°C			
700°C			
800°C			
1000°C			

5. Friction Error Test

Check Point	Before Tap	After Tap	SAT	UNSAT
200°C				
500°C				
700°C				
1000°C				

6. Position Error Test

Set check point at 700°C

Indicator Heading	Right Bank 90°	SAT	UNSAT
	Left Bank 90°		
	45° Climb		
	45° Dive		

7b. SATISFACTORY _____, UNSATISFACTORY _____.

UNIT 205
FUEL FLOW INDICATING SYSTEM

Part I. INSPECTION

1. Totalizer Indicator

	SAT	UNSAT
a.	____	____
b.	____	____
c.	____	____
d.	____	____

2. #4 Indicator

	SAT	UNSAT
a.	____	____
b.	____	____
c.	____	____
d.	____	____

3. #4 Transmitter

	SAT	UNSAT
a.	____	____
b.	____	____
c.	____	____

4. #5 Indicator

	SAT	UNSAT
a.	____	____
b.	____	____
c.	____	____
d.	____	____

5. #5 Transmitter

	SAT	UNSAT
a.	____	____
b.	____	____
c,	____	____

6. Electrical Wiring

	SAT	UNSAT
a.	____	____
b.	____	____
c.	____	____
d.	____	____

Part II. OPERATIONAL CHECK

5b. Totalizer Indicator indicates ____________ PFH fuel flow.
5c. System is SATISFACTORY ________, UNSATISFACTORY ___________.

6b. Totalizer Indicator indicates ____________ PFH fuel flow.
6c. System is SATISFACTORY ________, UNSATISFACTORY ___________.

8b. Totalizer Indicator indicates ____________ PFH fuel flow.
8c. System is SATISFACTORY ________, UNSATISFACTORY ___________.

5.

Part III. TROUBLESHOOTING

Trouble Switch	#4 Indicator	#5 Indicator	Totalizer
1	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
2	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
3	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
4	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
5	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
6	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
7	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
8	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.

Chart 1.

11.

Trouble Switch	Wire Number	Kind of Trouble
1		high resistance____, open____, shorted wires____.
2		high resistance____, open____, shorted wires____.
3		high resistance____, open____, shorted wires____.
4		high resistance____, open____, shorted wires____.
5		high resistance____, open____, shorted wires____.
6		high resistance____, open____, shorted wires____.
7		high resistance____, open____, shorted wires____.
8		high resistance____, open____, shorted wires____.

Chart 2

11.

Part IV. BENCH CHECK

Fuel Flow Indicator

Range: 0-12000

Dial: A251-B16A

FRICTION ERROR					SCALE ERROR			
PPH	Before Tap	After Tap	S	U	Trans. #1 Test	Exact °	S	U
0					15°			
400					47°			
800					79°			
1200					111°			
1600					143°			
2000					175°			
2075 (EZ)					180°			
2400					207°			
2800					239°			
5000					275°			
9000					315°			
11000					335°			

Chart 3

Position error is SATISFACTORY _____, UNSATISFACTORY _____.
The indicator is SATISFACTORY _____, UNSATISFACTORY _____.

UNIT 206
ENGINE PRESSURE RATIO SYSTEM

Part I. INSPECTION

1. Transducer	SAT	UNSAT	2. EPR Indicator	SAT	UNSAT	3. Electrical Wiring	SAT	UNSAT
a.	____	____	a.	____	____	a.	____	____
b.	____	____	b.	____	____	b.	____	____
c.	____	____	c.	____	____	c.	____	____
d.	____	____	d.	____	____	d.	____	____
			e.	____	____	e.	____	____
			f.	____	____			

Part II. OPERATIONAL CHECK

1a. The LEAK CHECK is SATISFACTORY _____, UNSATISFACTORY _____.

	SAT	UNSAT	INDICATOR READING
2a.	____	____	________________.
b.	____	____	________________.
c.	____	____	________________.
d.	____	____	________________.
e.	____	____	________________.
f.	____	____	________________.
g.	____	____	________________.
h.	____	____	________________.

Part III. TROUBLESHOOTING

	ERRATIC	INOPERATIVE	NORMAL
Switch #1 to IN position			
2b.	______	__________	_____
2c.	______	__________	_____
Switch #2 to IN position			
3b.	______	__________	_____
3c.	______	__________	_____

10. Switch #1 to IN position

a. Wire number ____________.
b. The trouble is _______________.

11. Switch #2 to IN position

a. Wire number ____________.
b. The trouble is _______________.

Part IV. BENCH CHECK INDICATOR

14.

Trans #1 Setting Degrees	Exact Degrees	Press Ratio Units On Indicator	Tolerances			Friction Error		Scale Error	
			Degrees	Before Tap	After Tap	S	U	S	U
51.0		1.20	1.20						
87.8		1.50	1.20						
124.6		1.80	1.20						
149.1		2.00	1.20						
173.7		2.20	1.20						
180.0EZ		2.25							
186.0		2.30	1.20						
198.3		2.40	1.20						
222.8		2.60	1.20						
271.9		3.00	1.20						
321.0		3.40	1.20						

SAT UNSAT

14a. Friction Error test ____ ____
b. Scale Error test ____ ____
c. Position Error test ____ ____

22.

Trans #1 Setting Degrees	Exact Degrees	Press Ratio Units On Indicator	Tolerances			Friction Error		Scale Error	
			Degrees	Before Tap	After Tap	S	U	S	U
68.0		0.02	3.6						
140.0		0.04	3.6						
184.0EZ		0.053							
212.0		0.06	3.6						
284.0		0.08	3.6						
356.0		0.10	3.6						

SAT UNSAT

22a. Friction Error test ____ ____
b. Scale Error test ____ ____
c. Position Error test ____ ____

UNIT 207
RESISTANCE-TYPE LIQUID QUANTITY SYSTEM

Part I. INSPECTION

1. Indicator	SAT	UNSAT	2. Elec Connectors	SAT	UNSAT	3. Elec Wiring	SAT	UNSAT
a.	____	____	a.	____	____	a.	____	____
b.	____	____	b.	____	____	b.	____	____
c.	____	____	c.	____	____	c.	____	____
d.	____	____	d.	____	____			
e.	____	____	e.	____	____			

Part II. OPERATIONAL CHECK

4. empty _____, full ____.
5. empty _____, full ____.
6. empty _____, full ____.

Part III. TROUBLESHOOTING

1. #1 switch IN
   a. Off scale empty ___, off scale full ___, low ___, high ___
   b. Indicator moves ___, does not move ____.
2. #2 switch IN
   a. Off scale empty ___, off scale full ___, low ___, high ___.
   b. Indicator moves ___, does not move ___.
3. #3 switch IN
   a. Off scale empty ___, off scale full ___, low ___, high ___.
   b. Indicator moves ___, does not move ___.
4. #4 switch IN
   a. Off scale empty ___, off scale full ___, low ___, high ___.
   b. Indicator moves ___, does not move ___.

10. Trouble

Switch	Open, Short, etc.	Wire Number or Numbers	
1.	________________	________________	________________
2.	________________	________________	________________
3.	________________	________________	________________
4.	________________	________________	________________

Part IV. Bench Check

4a. empty _____, full _____.
5a. empty _____, full _____.
6. sat _____, unsat ____.

22. Resistance is __________ Ohms.
    a. Sat ____, Unsat ____.

25a. Sat ____, Unsat ____.

UNIT 208
CAPACITANCE LIQUID QUANTITY SYSTEM

Part I. INSPECTION

1. FUEL QUANTITY INDICATOR

	SAT	UNSAT
a.	____	____
b.	____	____
c.	____	____

2. TOTAL/SELECT FUEL QUANTITY INDICATOR

	SAT	UNSAT
a.	____	____
b.	____	____
c.	____	____
d.	____	____

3. INTERMEDIATE DEVICES

a.	____	____

4. ELECTRICAL WIRING

a.	____	____
b.	____	____
c.	____	____
d.	____	____

Part II. OPERATIONAL CHECK

g.(1) L.W. __________

R.W. __________

(2) FWD __________

AFT __________

(3) SUM __________

(4) TOTALIZER __________

(5) DIFFERENCE __________

(6) SAT ____ UNSAT ____

h.(1) TOT __________ S ___ U ___

SEL __________ S ___ U ___

FWD __________ S ___ U ___

AFT __________ S ___ U ___

Part III. TROUBLESHOOTING

		Trouble Location		Kind of Trouble
SW #	TROUBLE INDICATION	PROBE SIDE or PWR SIDE	Wire Number	SHORT OR OPEN

Chart 1.

Part IV. CALIBRATION AND BENCH CHECK

3. b The dry capacitance reading is ______________PF.
(1) SAT _____ UNSAT _____

e Dry capacitance reading is ________________PF.
(1) SAT _____ UNSAT _____

4. r Capacitance indicator indicates _______________PF.

s For FULL, the capacitance is ______________PF.

5. l Dry capacitance reading is _____________PF.
(1) SAT _____ UNSAT _____

o Dry capacitance reading is _____________PF.
(1) SAT _____ UNSAT _____

6. r Dry value is ___________PF.

s. For FULL, the capacitance is ____________PF.

UNIT 209
VERTICAL SCALE ENGINE INSTRUMENTS
Section A. INSPECTION, OPERATIONAL CHECK AND TROUBLESHOOTING

Part I. INSPECTION

1. EGT INDICATOR

	SAT	UNSAT
a.	___	___
b.	___	___
c.	___	___
d.	___	___

2. FUEL FLOW INDICATOR

	SAT	UNSAT
a.	___	___
b.	___	___
c.	___	___
d.	___	___

3. N-1 & N-2 TACH INDICATOR

	N-1 SATISFACTORY	N-2 SATISFACTORY	N-1 UNSATISFACTORY	N-2 UNSATISFACTORY
a.	___	___	___	___
b.	___	___	___	___
c.	___	___	___	___
d.	___	___	___	___

4. EPR INDICATOR

a.	___	___
b.	___	___
c.	___	___
d.	___	___

5. CIRCUIT BREAKERS

a.	___	___
b.	___	___

6. EGT, N-1 & N-2 INDICATORS

a. EGT	___	___
b. N-1	___	___
c. N-2	___	___

Part II. OPERATIONAL CHECK

6a. The 28 VDC power lamp glows ___, does not glow___.

6b. The 115 VAC 400 Hz power lamp glows ___, does not glow ___.

7a. ALL are removed from view ___, are not removed from view ___.

8b. Increase in temp ___, decrease in temp ___, NO change in temp ___.

9a. Increase in RPM ___, decrease in RPM ___, NO change in RPM ___.

10a. Increase in RPM ___, decrease in RPM ___, NO change in RPM ___.

11a. Increase in EPR ___, decrease in EPR ___, NO change in EPR ___.

Part III. TROUBLESHOOTING

Trouble Switch #	Indication of trouble on #1 engines
1.	Fuel flow OFF FLAG shows
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	
17.	

Chart 1.

Check with INSTRUCTOR before removing power.

18.

Trouble Switch #	Location of Trouble (Wire Number)	OPEN	HIGH RESISTANCE
1.	1E500A20 1E500B20		
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
17.			

Chart 2.

Check troubles with INSTRUCTOR.

Section B. CONVERTER BENCH CHECK

1b.(1) N-1 motor excitation test (2) motor excitation test

Eng Position MOT EXC SW 38	Actual VTVM Indications N1	N2	Results (S or U) N1	N2
ENG 1				
ENG 2				
ENG 3				
ENG 4				

Table 1. Pilot's N-1 and N-2 Motor Excitation Tests.

1b.(4) N-1 control phase test (5) N-2 control phase test

AMPL	Test Point % RPM SW 15	Actual F/U POT Control Ratio Indication				Results (S or U)			
		1	2	3	4	1	2	3	4
N 1	.20								
R A	50								
T I	90								
OC	100								
N 2	20								
R A	50								
T I	90								
O	100								

Table 2. Pilot's N-1 and N-2 Control Phase Test.

1c.(1) Motor Excitation test (EGT)

Engine Position MOT EXC SW 38	Actual VTVM Indications	Results (S or U)
ENG 1		
ENG 2		
ENG 3		
ENG 4		

Table 3. Pilot's EGT Motor Excitation Test.

1c.(3) Control Phase Test (EGT)

Test Point EGI C SW 1	Actual F/U POT Control (26) Ratio Indications				Results (S or U)			
	1	2	3	4	1	2	3	4
100°C								
300°C								
400°C								
600°C								

Table 4. Pilot's Exhaust Gas Temperature Control Phase Test.

1d.(1) Motor Excitation Tests (Fuel Flow).

Engine Position MOT EXC SW 38	Actual VTVM Indications	Results (S or U)
ENG 1		
ENG 2		
ENG 3		
ENG 4		

Table 5. Pilot's Fuel Flow Motor Excitation Tests.

1d.(3) Control Phase Tests (Fuel Flow).

Test Points Fuel Flow PPH SW 38	Actual CT (12) Indications in degrees				Results (S or U)			
	1	2	3	4	1	2	3	4
400								
3000								
6000								
8000								
12000								

Table 6. Pilot's Fuel Flow Control Phase Tests.

HANDOUT
3ABR32531-HO-200-1

Technical Training

Avionics Instrument Specialist

BLOCK II
ENGINE INSTRUMENTS

11 September 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

524

Flt Tng Devices/Instrument Branch
Chanute AFB, Illinois

3ABR32531-HO-200-1

This handout provides illustrations supporting the instructor's presentation of each lesson. The booklet is yours to keep, so feel free to make any notations that will better your understanding when you study.

CONTENTS

UNIT	TITLE	PAGE
201	Position Indicating Systems	3
202	Pressure Indicating Systems	10
203	Tachometer Systems	20
204	Temperature Indicating Systems	26
205	Fuel Flow Indicating Systems	36
206	Engine Pressure Ratio Indicating Systems	41
207	Resistance-Type Liquid Quantity System	49
208	Capacitance Liquid Quantity System	52
209	Vertical Scale Engine Instrument Systems	62

516

OPR: 3360 TCHTG
DISTRIBUTION: X
3360TCHTG/TTGU-F - 500; TTVSA - 1

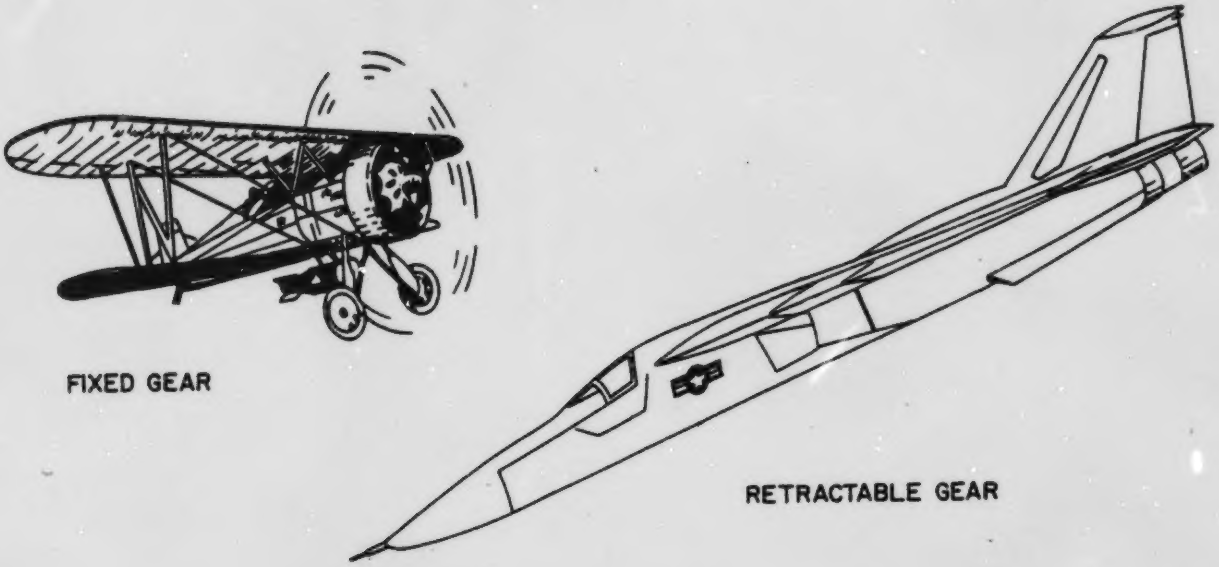

FIXED GEAR
RETRACTABLE GEAR

Figure 1. Types of Landing Gears.

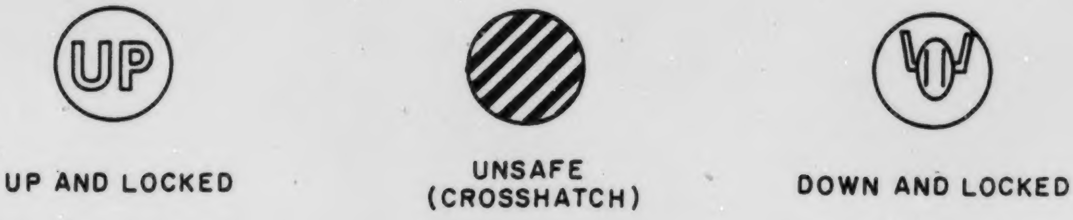

UP
UP AND LOCKED
UNSAFE (CROSSHATCH)
DOWN AND LOCKED

Figure 2. Wheel Position Indications.

526.

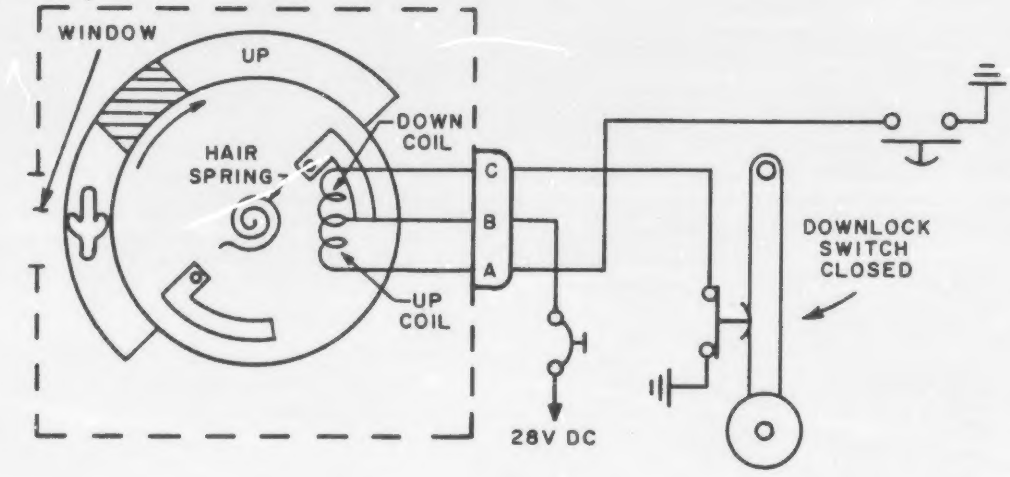

WINDOW
UP
DOWN COIL
HAIR SPRING
UP COIL
C
B
A
DOWNLOCK SWITCH CLOSED
28V DC

Figure 3. Wheel Down and Locked.

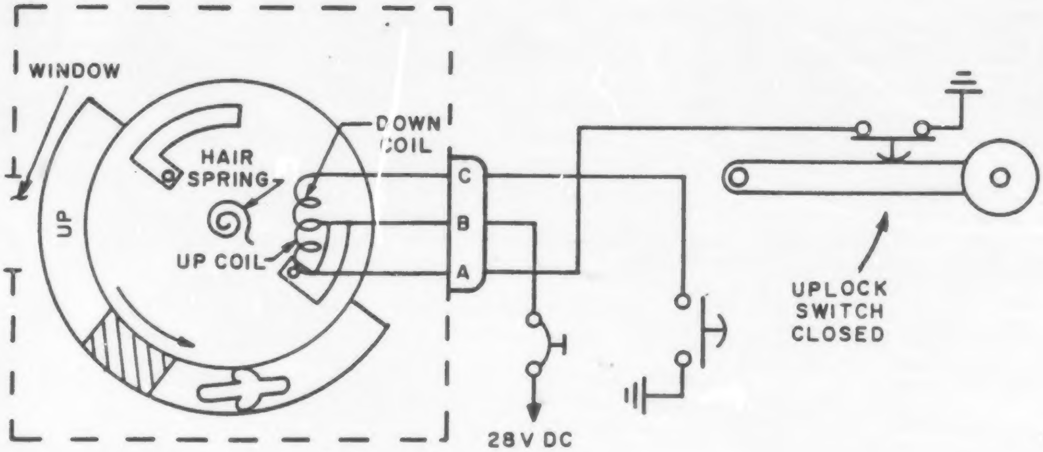

WINDOW
UP
DOWN COIL
HAIR SPRING
UP COIL
C
B
A
UPLOCK SWITCH CLOSED
28V DC

Figure 4. Wheel Up and Locked.

527

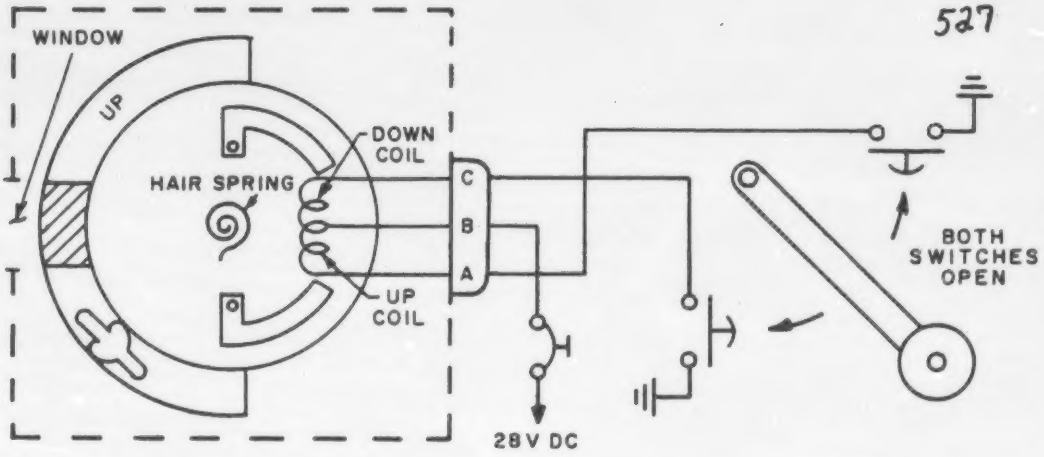

WINDOW
UP
DOWN COIL
HAIR SPRING
C
B
A
UP COIL
BOTH SWITCHES OPEN
28V DC

Figure 5. Wheel in Unsafe Position.

NOTES

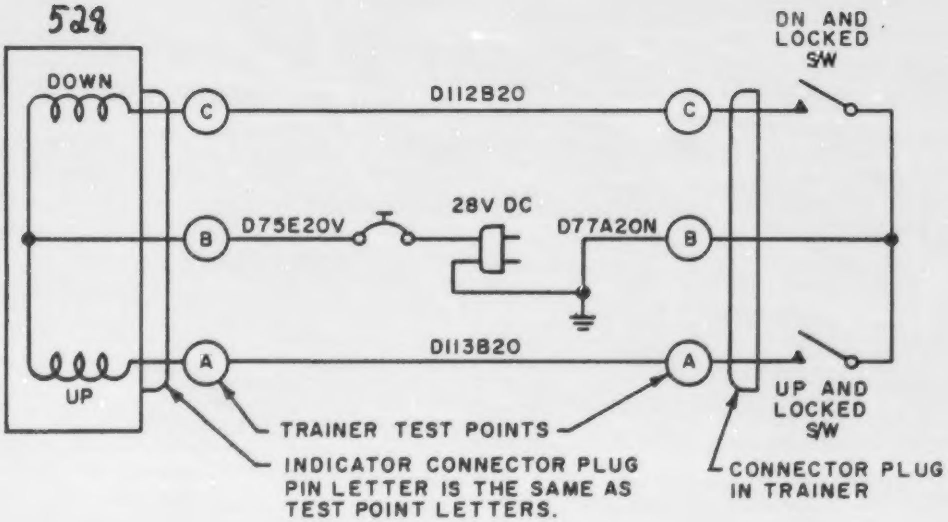

DOWN
UP
C
B
A
D112B20
D75E20V
28V DC
D77A20N
D113B20
C
B
A
DN AND LOCKED S/W
UP AND LOCKED S/W
TRAINER TEST POINTS
INDICATOR CONNECTOR PLUG PIN LETTER IS THE SAME AS TEST POINT LETTERS.
CONNECTOR PLUG IN TRAINER

Figure 6. Wheel Position Indicator Trainer Schematic.

NOTES

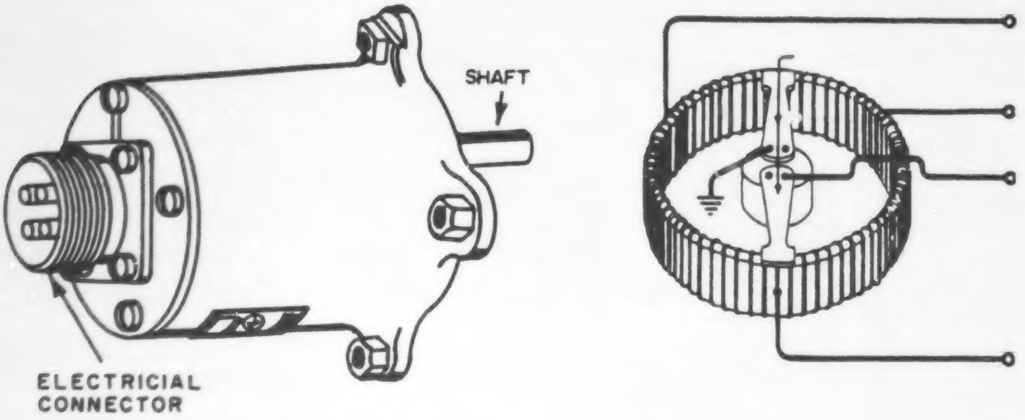

SHAFT
ELECTRICIAL CONNECTOR

Figure 7. Flap Position Transmitter.

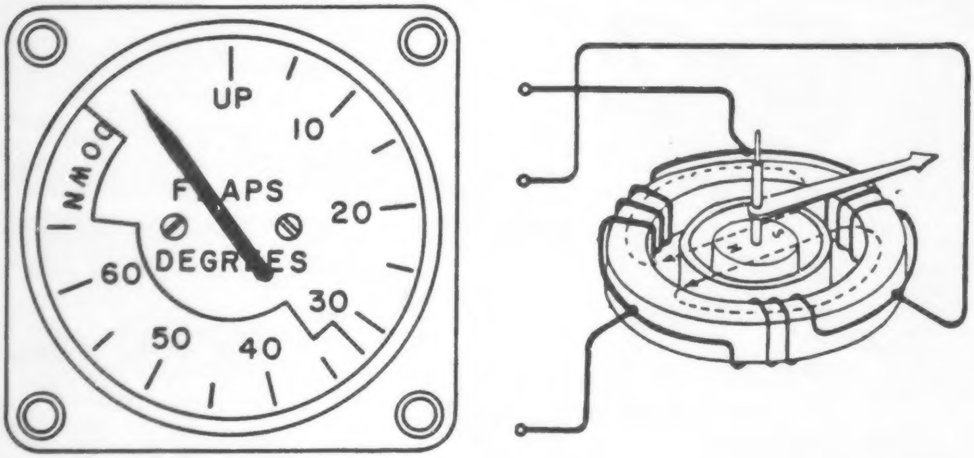

UP
10
20
30
40
50
60
DOWN
FLAPS
DEGREES

Figure 8. Flap Position Indicator.

530

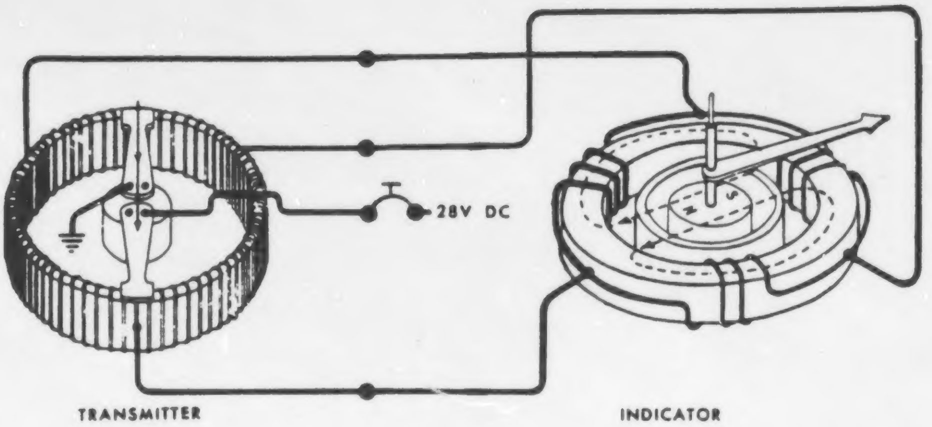

28V DC
TRANSMITTER
INDICATOR

Figure 9. Flap Transmitter and Indicator Connections.

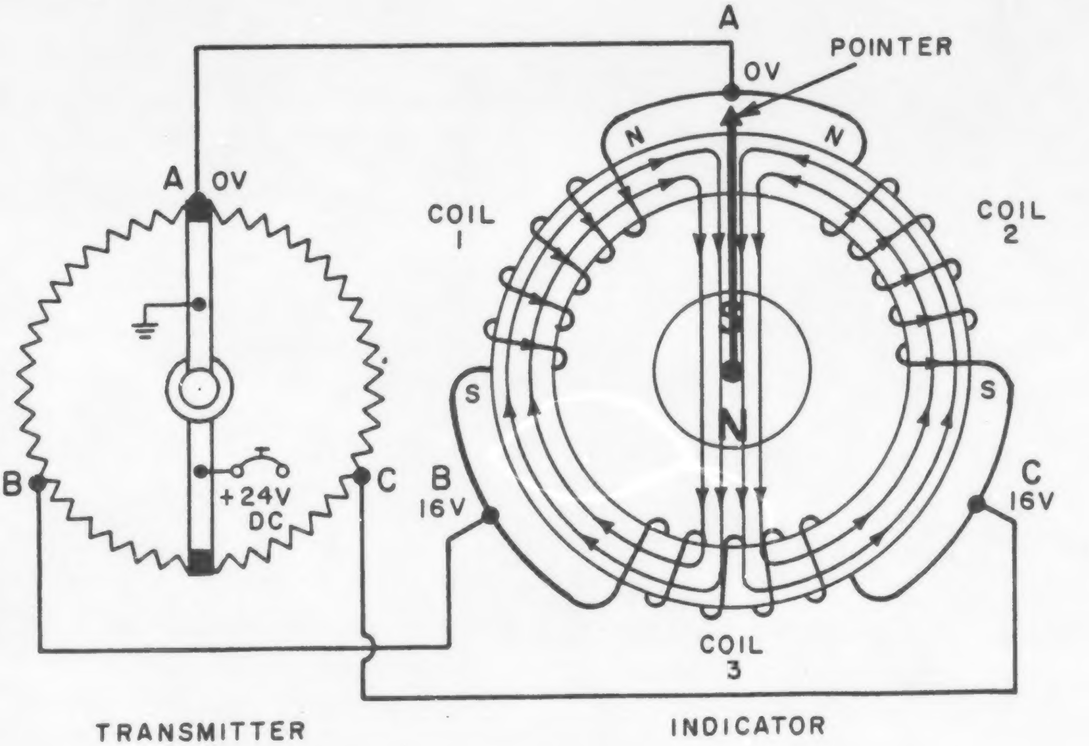

A
POINTER
OV
N
N
A
OV
COIL
1
COIL
2
S
N
S
S
B
C
B
16V
+24V
DC
C
16V
COIL
3
TRANSMITTER
INDICATOR

Figure 10. Flaps at Midscale.

552

531

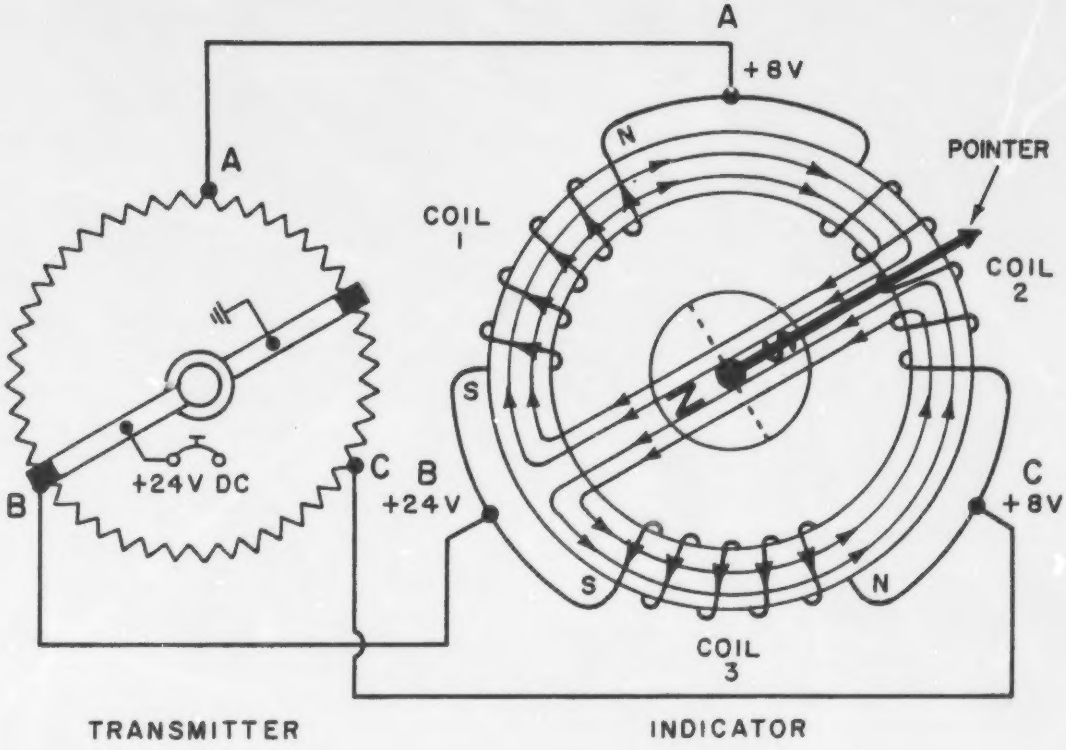

A
+8V
POINTER
A
COIL
1
COIL
2
+24V DC
C
B
+24V
C
+8V
B
S
N
S
N
N
S
COIL
3
TRANSMITTER
INDICATOR

Figure 11. Flaps in Down Position.

NOTES

UNIT 202

PRESSURE INDICATING SYSTEMS

DIRECT PRESSURE SYSTEM	USED FOR
1. OIL PRESSURE	LUBRICATING OIL TO THE MOVING ENGINE PARTS.
2. FUEL PRESSURE	FUEL PRESSURE TO ENGINE CARBURETOR
3. VACUUM PRESSURE	AIR DRIVEN GYROSCOPIC FLIGHT INSTRUMENTS.
4. MANIFOLD PRESSURE	INTAKE PRESSURE TO ENGINE MANIFOLD
5. HYDRAULIC PRESSURE	LANDING GEAR, FLAPS, BRAKES, ETC.

Figure 12. Aircraft Uses of Direct Reading Pressure Gages.

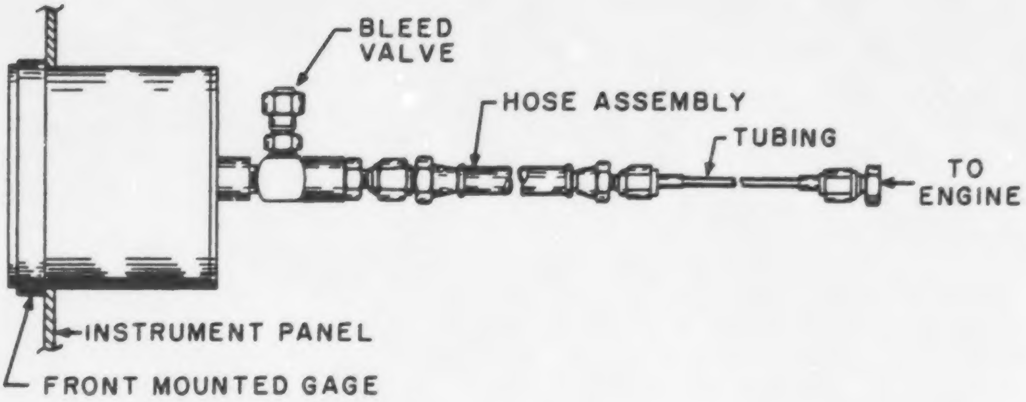

BLEED VALVE
HOSE ASSEMBLY
TUBING
TO ENGINE
INSTRUMENT PANEL
FRONT MOUNTED GAGE

Figure 13. Direct Reading Gage Connection to Engine.

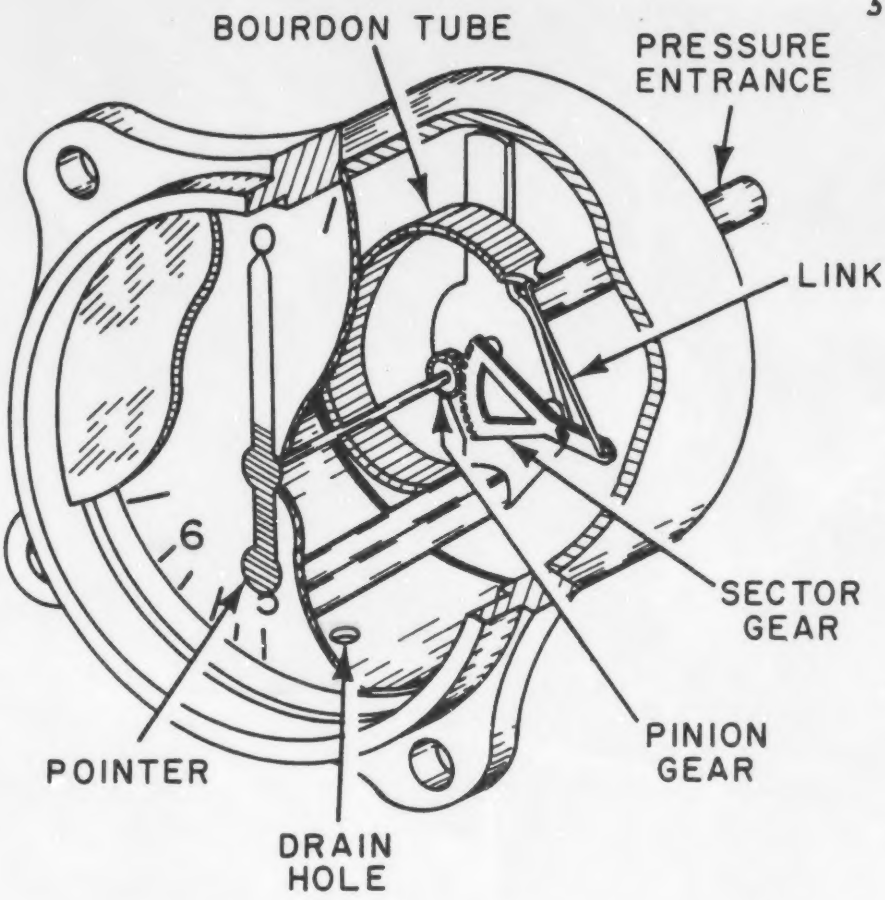

BOURDON TUBE
PRESSURE ENTRANCE
LINK
6
5
SECTOR GEAR
PINION GEAR
POINTER
DRAIN HOLE

Figure 14. Cutaway of Direct Reading Pressure Gage.

NOTES

534

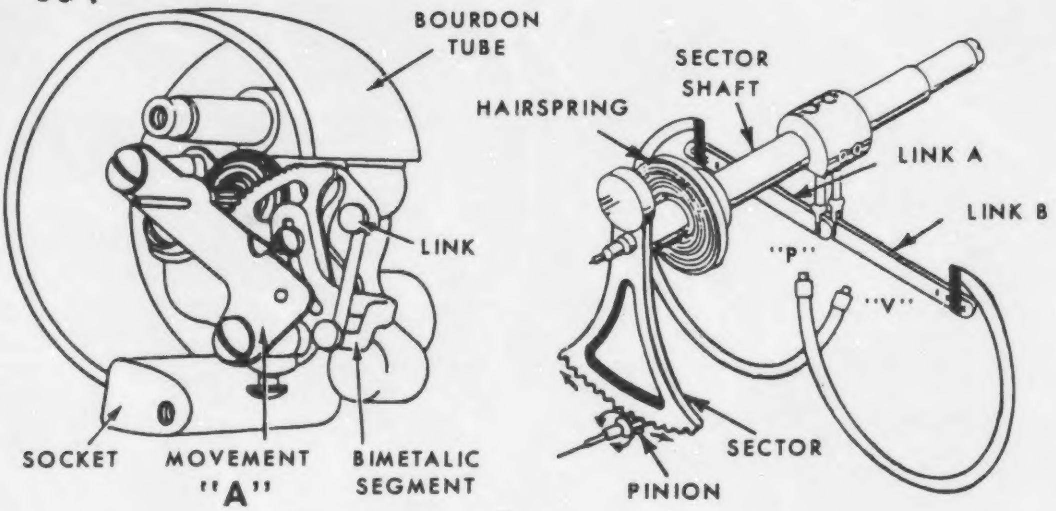
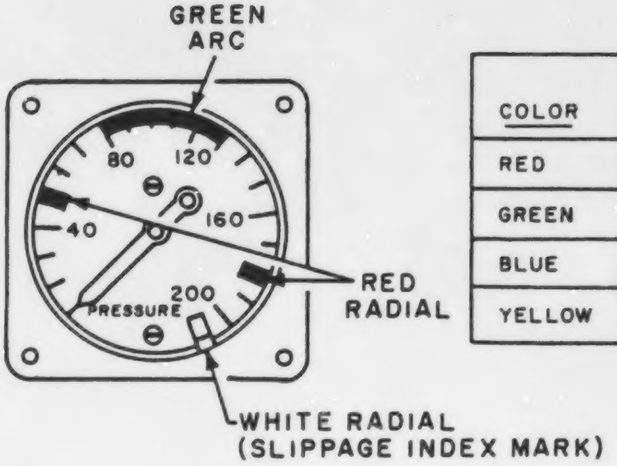

BOURDON TUBE
SECTOR SHAFT
HAIRSPRING
LINK A
LINK B
LINK
"P"
"V"
SOCKET
MOVEMENT "A"
BIMETALIC SEGMENT
SECTOR
PINION

Figure 15. Direct Reading Pressure Gage Bourdon Tube Arrangements.

NOTES

556

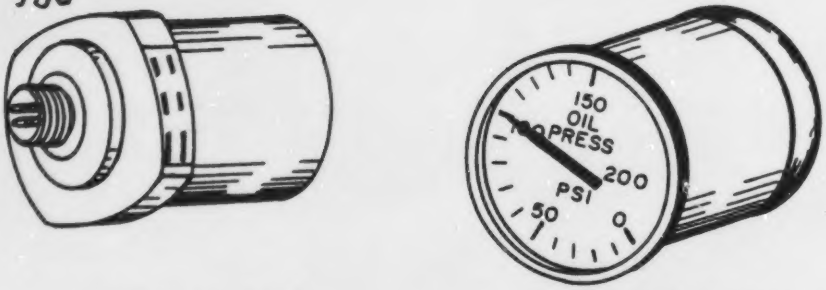

GREEN ARC
80
120
40
160
200
PRESSURE
RED RADIAL
WHITE RADIAL
(SLIPPAGE INDEX MARK)

COLOR	OPERATION	AIRCRAFT USED ON
RED	PROHIBITED	ALL TYPES
GREEN	NORMAL	ALL TYPES
BLUE	AUTO-LEAN	PROPELLER
YELLOW	UNDESIREABLE	ALL TYPES

Figure 16. Instrument Range Markings.

NOTES

536·


150
OIL
100
PRESS
200
PSI
50
0

TRANSMITTER

INDICATOR

Figure 17. Synchro Pressure Transmitter and Indicator.

NOTES

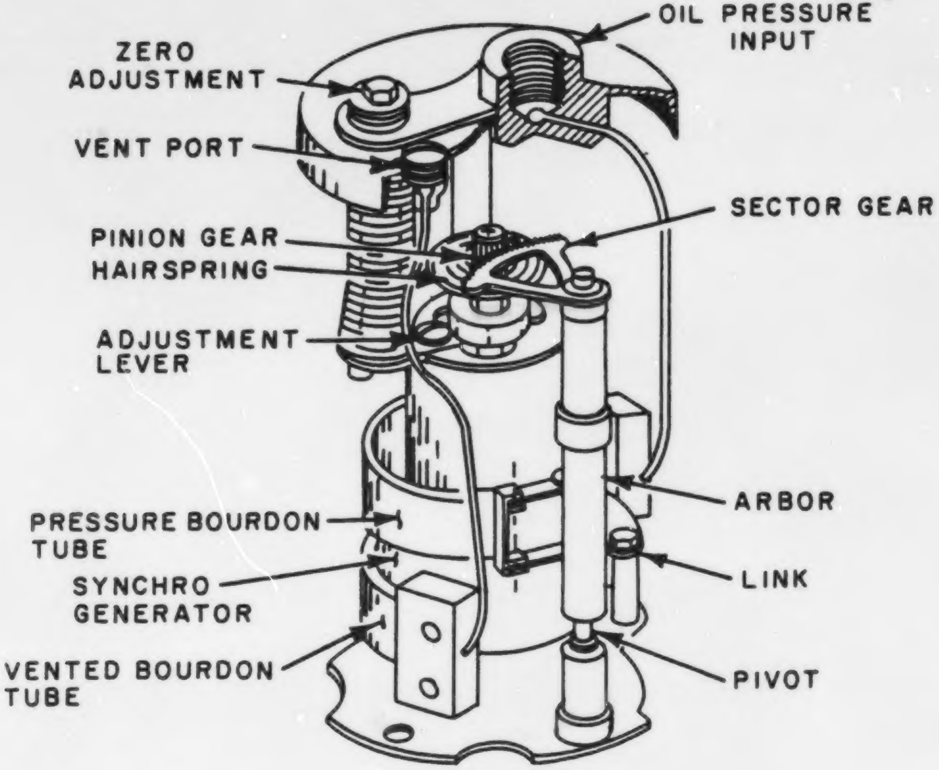

OIL PRESSURE INPUT
ZERO ADJUSTMENT
VENT PORT
SECTOR GEAR
PINION GEAR
HAIRSPRING
ADJUSTMENT LEVER
ARBOR
PRESSURE BOURDON TUBE
LINK
SYNCHRO GENERATOR
VENTED BOURDON TUBE
PIVOT

Figure 18. Transmitter Construction.

NOTES

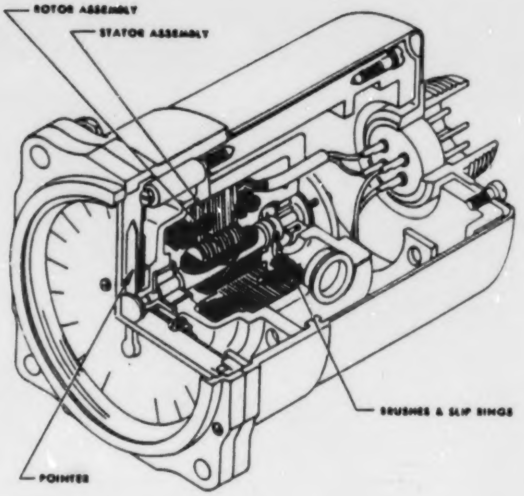

ROTOR ASSEMBLY
STATOR ASSEMBLY
BRUSHES & SLIP RINGS
POINTER

Figure 19. Cutaway of Synchro Indicator.

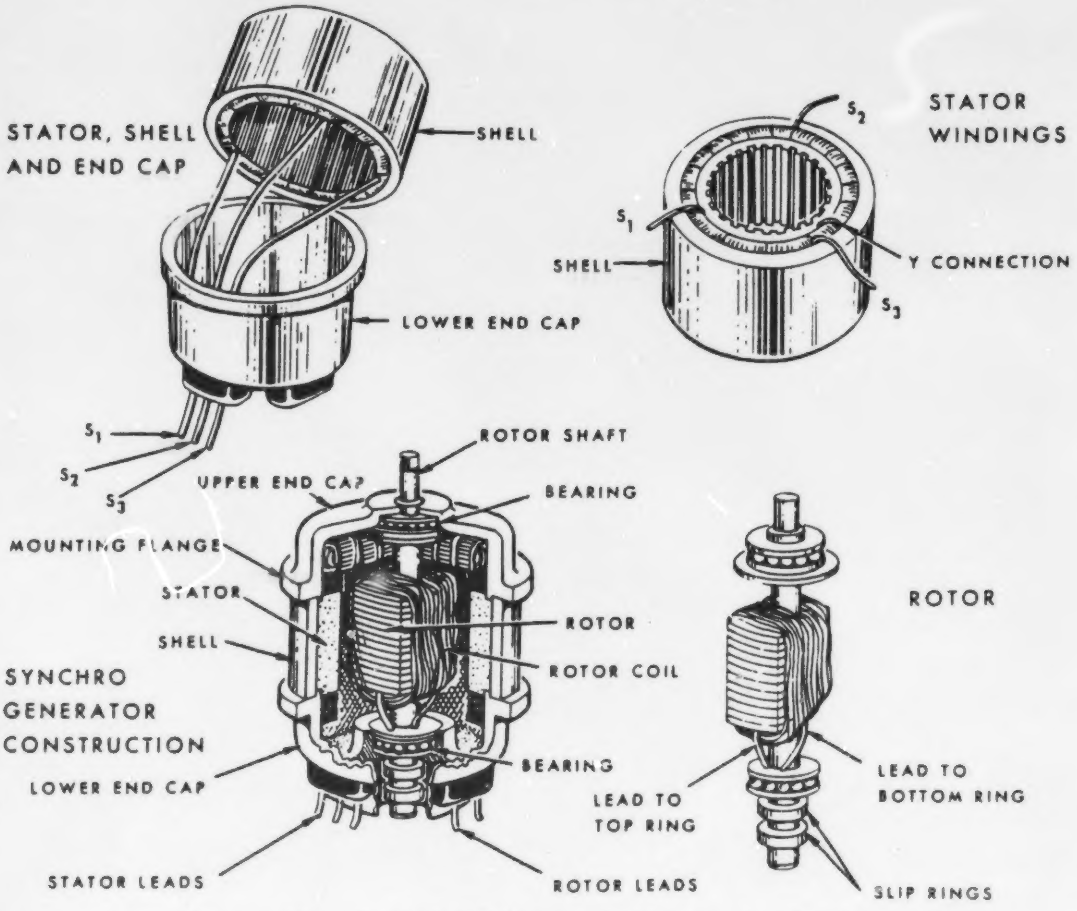

STATOR, SHELL AND END CAP
SHELL
LOWER END CAP
S_1
S_2
S_3
STATOR WINDINGS
S_2
S_1
SHELL
Y CONNECTION
S_3
ROTOR SHAFT
UPPER END CAP
BEARING
MOUNTING FLANGE
STATOR
SHELL
ROTOR
ROTOR COIL
SYNCHRO GENERATOR CONSTRUCTION
LOWER END CAP
BEARING
STATOR LEADS
ROTOR LEADS
ROTOR
LEAD TO TOP RING
LEAD TO BOTTOM RING
SLIP RINGS

Figure 20. Exploded View of Indicator Synchro.

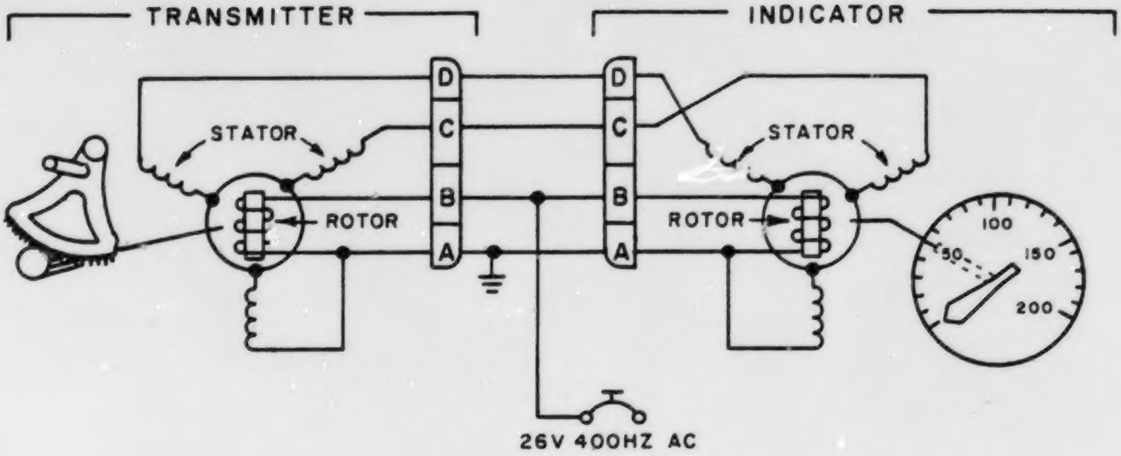

TRANSMITTER
INDICATOR
STATOR
STATOR
ROTOR
ROTOR
D
C
B
A
D
C
B
A
100
50
150
200
26V 400HZ AC

Figure 21. Wiring Schematic of Synchro Indicating System.

NOTES

540

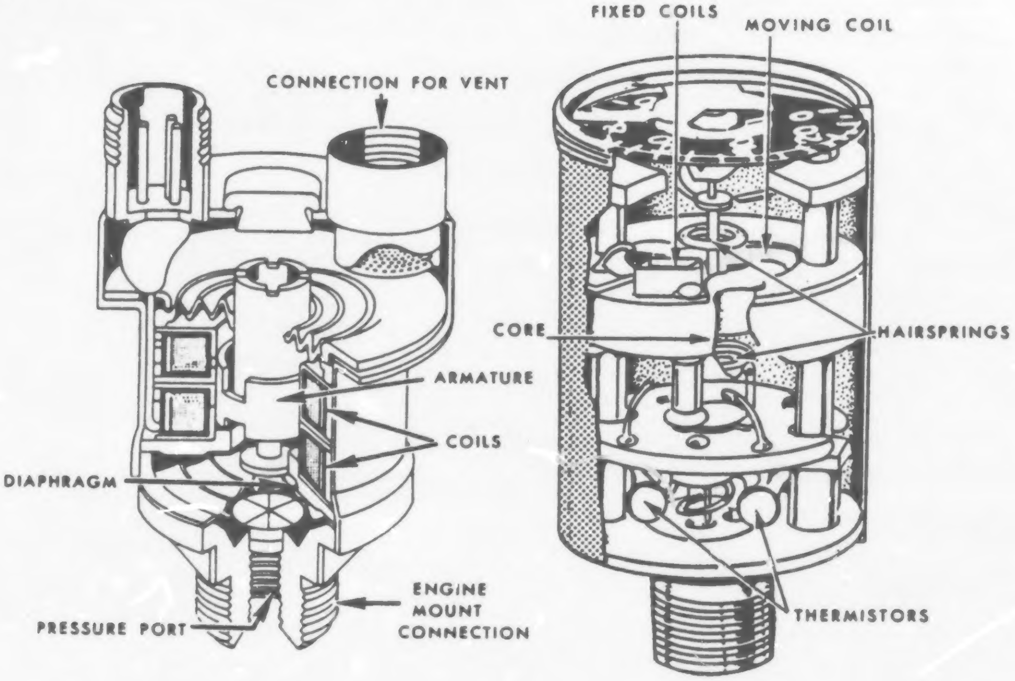

CONNECTION FOR VENT
ARMATURE
COILS
DIAPHRAGM
ENGINE MOUNT CONNECTION
PRESSURE PORT
FIXED COILS
MOVING COIL
CORE
HAIRSPRINGS
THERMISTORS

Figure 22. Variable Reluctance Transmitter and Indicator Cutaways.

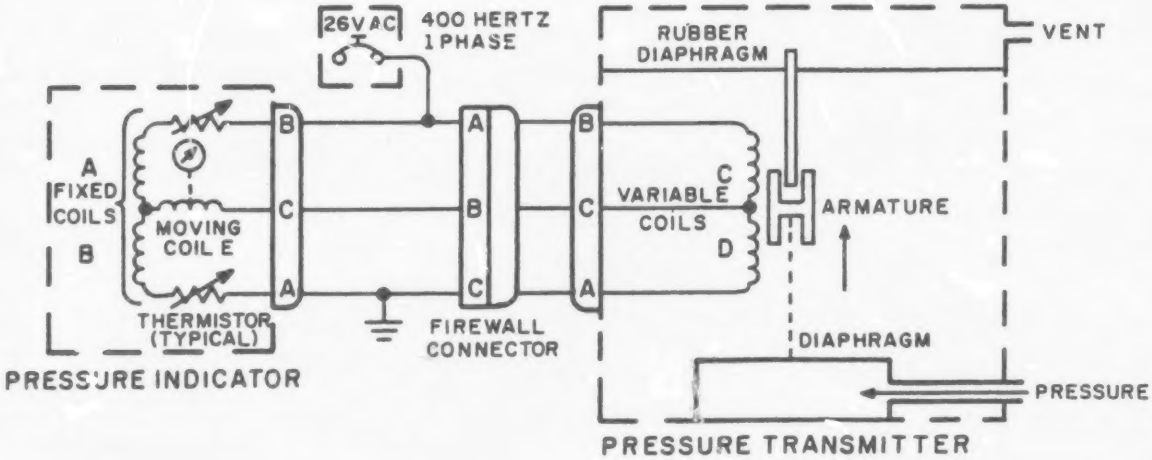

26V AC
400 HERTZ
1 PHASE
A
FIXED COILS
B
MOVING COIL E
THERMISTOR (TYPICAL)
PRESSURE INDICATOR
B
C
A
A
B
C
FIREWALL CONNECTOR
B
C
A
RUBBER DIAPHRAGM
VENT
C
VARIABLE COILS
D
ARMATURE
DIAPHRAGM
PRESSURE
PRESSURE TRANSMITTER

Figure 23. Wiring Schematic of Variable Reluctance Pressure Indicating System.

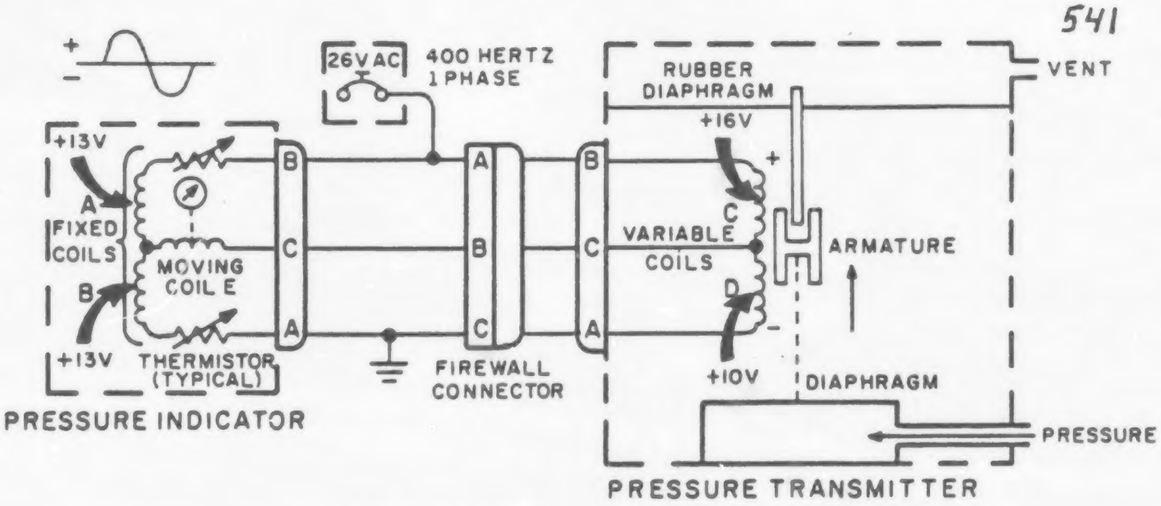

+
−
26V AC
400 HERTZ
1 PHASE
VENT
RUBBER DIAPHRAGM
+16V
+
+13V
A
FIXED COILS
B
MOVING COIL E
+13V
THERMISTOR (TYPICAL)
PRESSURE INDICATOR
B
C
A
A
B
C
FIREWALL CONNECTOR
B
C
A
C
VARIABLE COILS
D
−
ARMATURE
+10V
DIAPHRAGM
PRESSURE
PRESSURE TRANSMITTER

Figure 24. Variable Reluctance System Operation.

NOTES

UNIT 203

TACHOMETER SYSTEMS

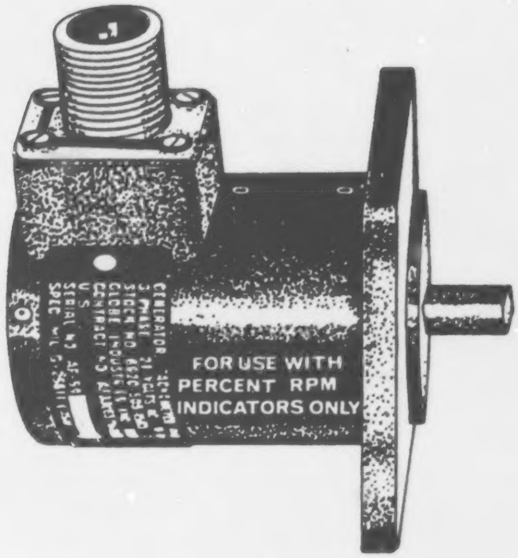
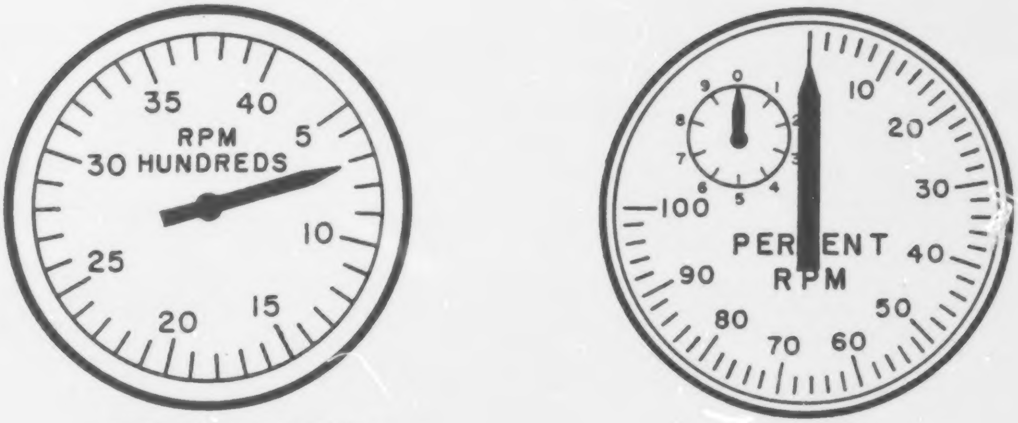

FOR USE WITH
PERCENT RPM
INDICATORS ONLY

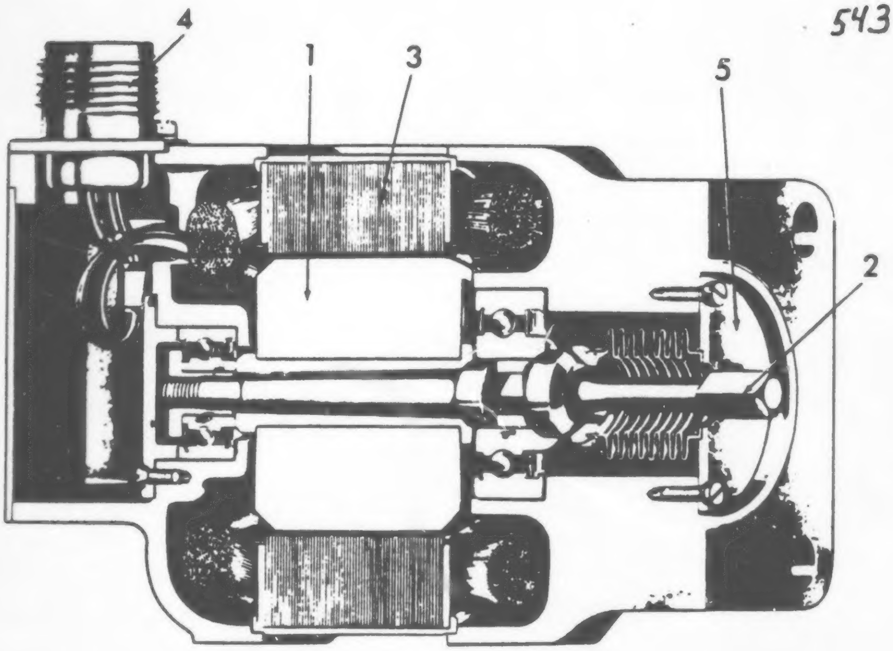
Figure 25. Tachometer Generator.


RPM
HUNDREDS
5
10
15
20
25
30
35
40
PERCENT
RPM
0
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100

RECIPROCATING ENGINES

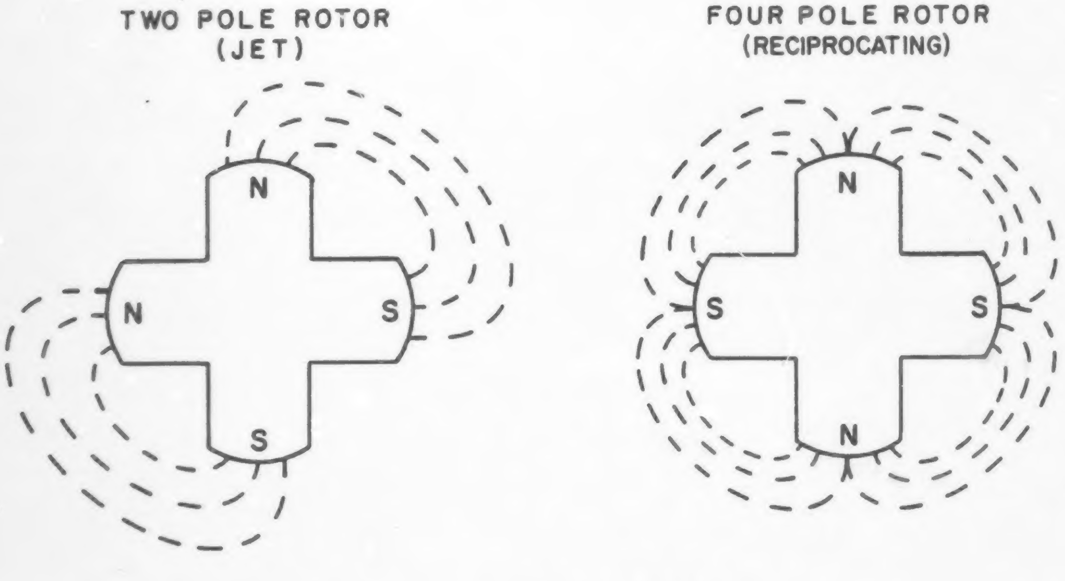
JET ENGINES

Figure 26. Tachometer Indicators.



1. MAGNET (ROTOR)
2. DRIVE SHAFT
3. STATOR
4. ELECTRICAL CONNECTOR RECEPTACLE
5. OIL SEAL

Figure 27. Cutaway of Tachometer Generator.


TWO POLE ROTOR (JET)

FOUR POLE ROTOR (RECIPROCATING)

Figure 28. Two- and Four-Pole Rotors.

544

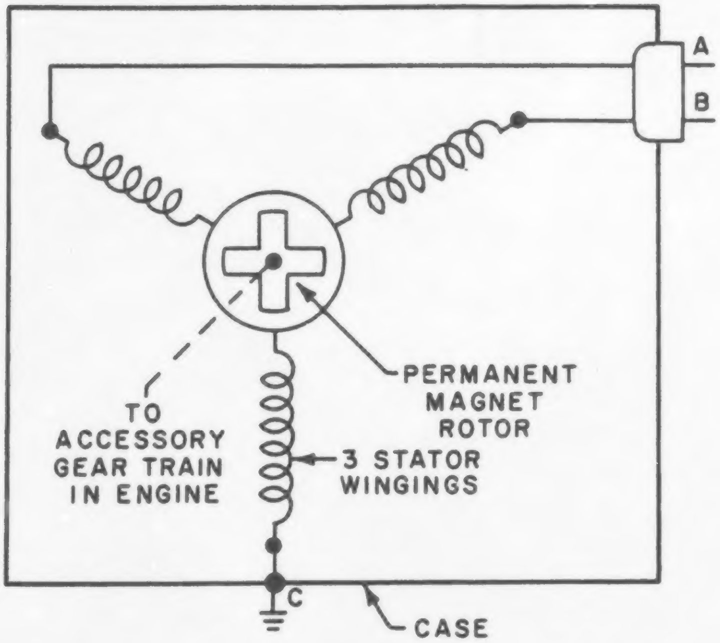

A
B
PERMANENT MAGNET ROTOR
TO ACCESSORY GEAR TRAIN IN ENGINE
3 STATOR WINGINGS
C
CASE

Figure 29. Tachometer Generator Internal Wiring Schematic (Jet).

NOTES

556

545

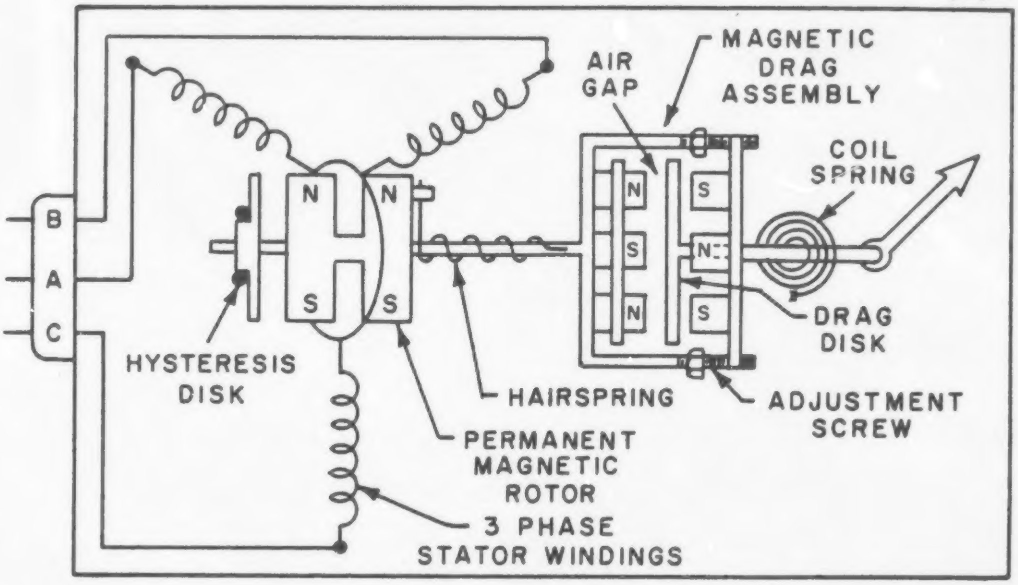

MAGNETIC DRAG ASSEMBLY
AIR GAP
COIL SPRING
B
A
C
N
N
S
S
N
S
N
S
N
S
HYSTERESIS DISK
HAIRSPRING
DRAG DISK
ADJUSTMENT SCREW
PERMANENT MAGNETIC ROTOR
3 PHASE STATOR WINDINGS

Figure 30. Tachometer Indicator Components and Wiring.

NOTES

567

546

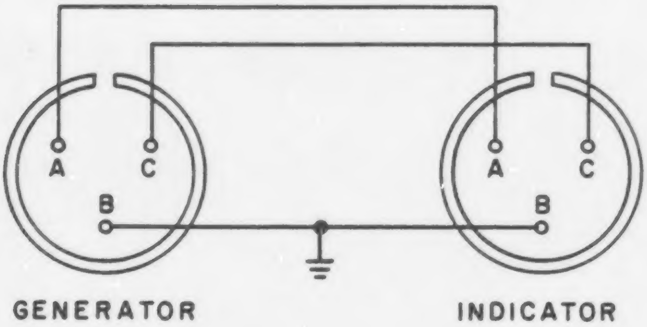

A
C
B
A
C
B
GENERATOR
INDICATOR

Figure 31. Three-Wire Tachometer System (Reciprocating).

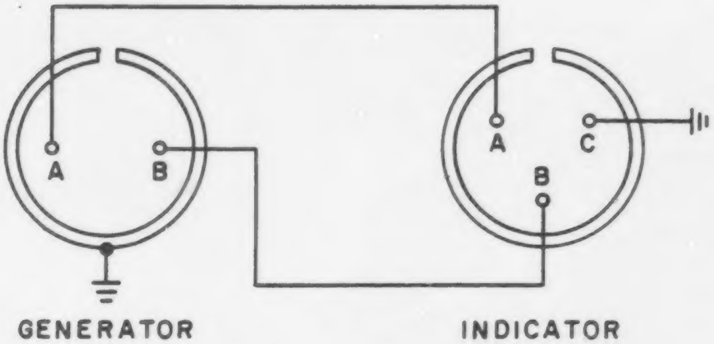

A
B
A
C
B
GENERATOR
INDICATOR

Figure 32. Two-Wire Tachometer System (Jet).

588

547

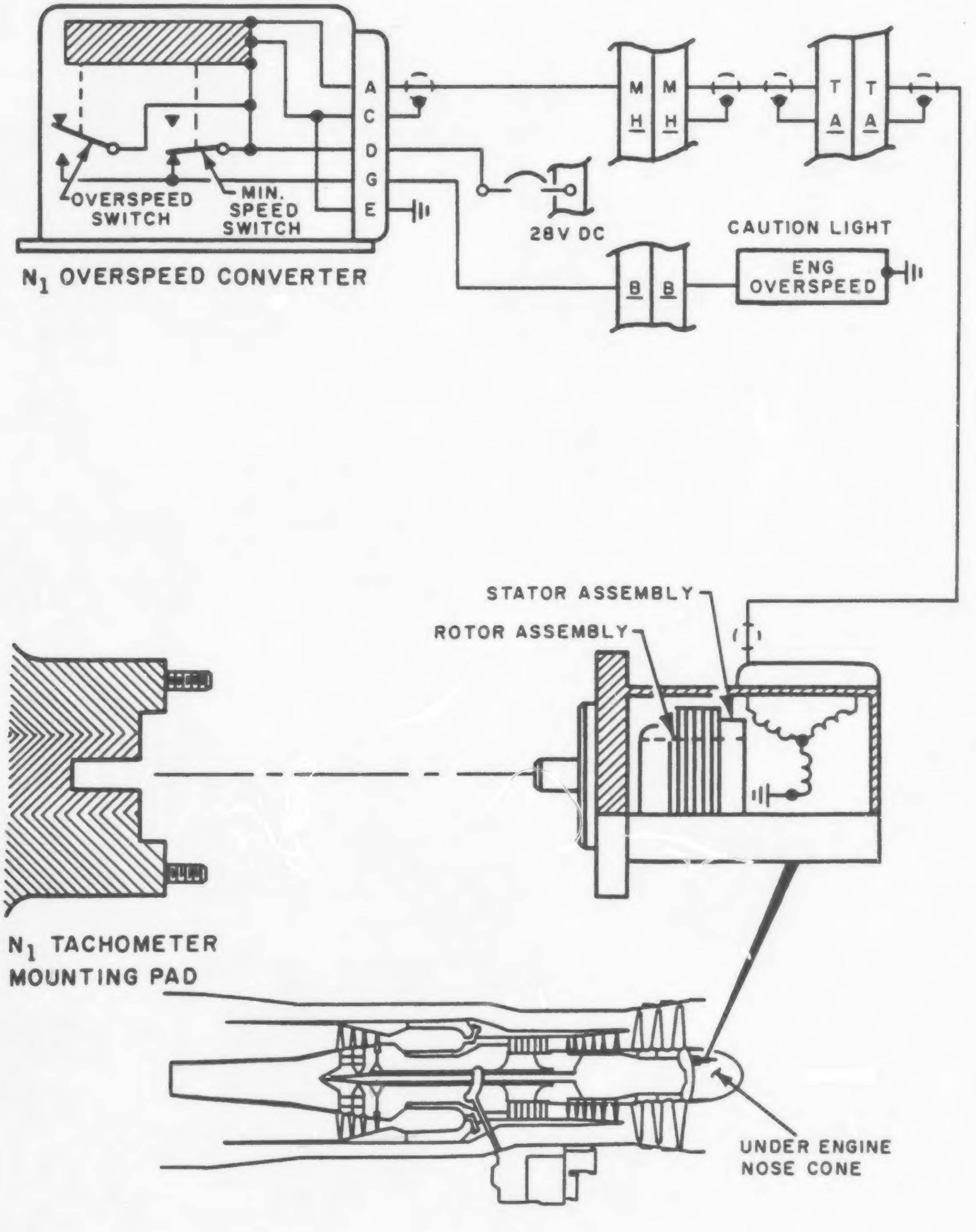

A
C
D
G
E
OVERSPEED SWITCH
MIN. SPEED SWITCH
N1 OVERSPEED CONVERTER
M M
H H
T T
A A
28V DC
CAUTION LIGHT
ENG OVERSPEED
B B
STATOR ASSEMBLY
ROTOR ASSEMBLY
N1 TACHOMETER MOUNTING PAD
UNDER ENGINE NOSE CONE

Figure 33.

569

UNIT 204

TEMPERATURE INDICATING SYSTEMS

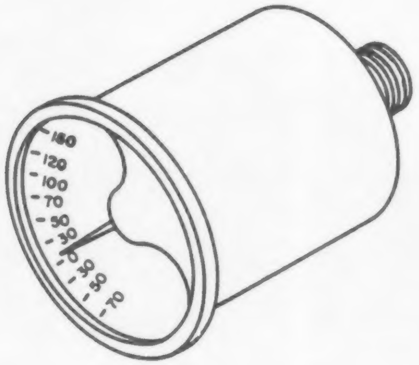

150
120
100
70
50
30
0
30
50
70

Figure 34. Typical Resistance Thermometer Indicator.

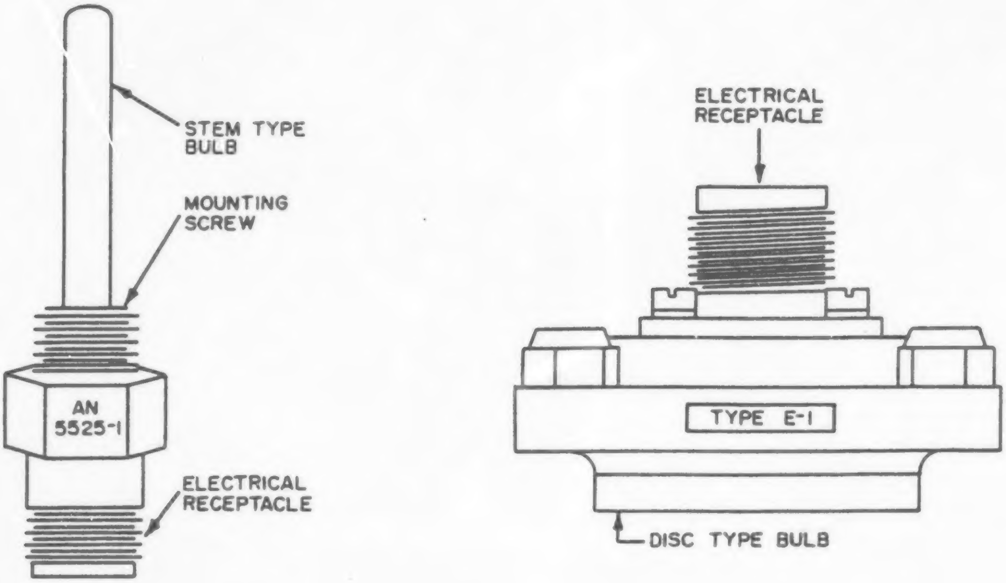

STEM TYPE BULB
MOUNTING SCREW
AN 5525-1
ELECTRICAL RECEPTACLE
ELECTRICAL RECEPTACLE
TYPE E-1
DISC TYPE BULB

Figure 35. Types of Resistance Thermometer Bulbs.

NOTES

549

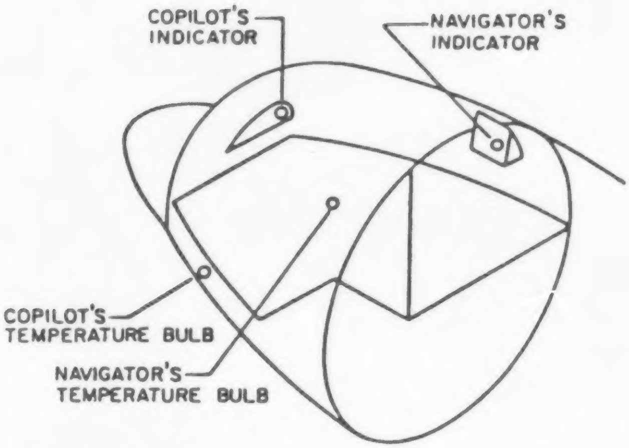

COPILOT'S INDICATOR
NAVIGATOR'S INDICATOR
COPILOT'S TEMPERATURE BULB
NAVIGATOR'S TEMPERATURE BULB

Figure 36. Typical Free Air Temperature System.

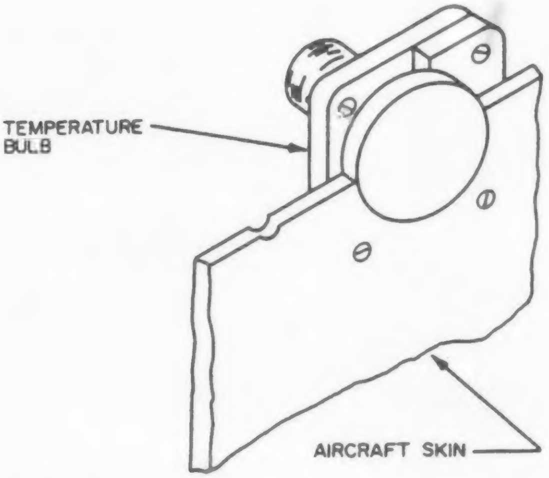

TEMPERATURE BULB
AIRCRAFT SKIN

Figure 37. Free Air Bulb Installation.

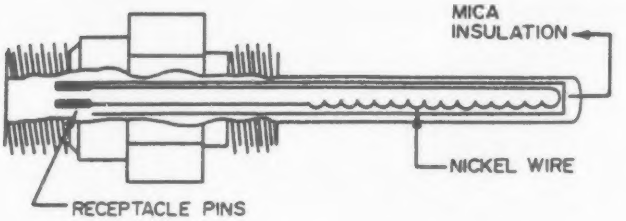

MICA INSULATION
NICKEL WIRE
RECEPTACLE PINS

Figure 38. Temperature Bulb Construction.

571

NOTES 550

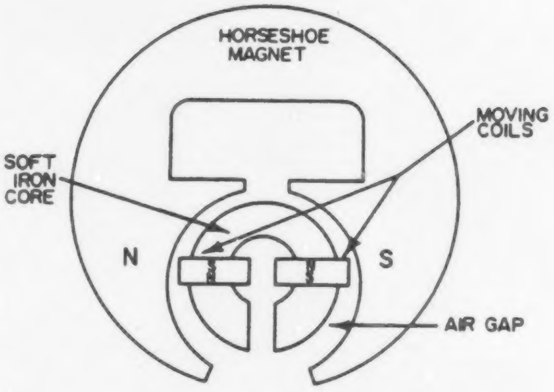

HORSESHOE MAGNET
MOVING COILS
SOFT IRON CORE
N
S
AIR GAP

Figure 39. Ratiometer Movement.

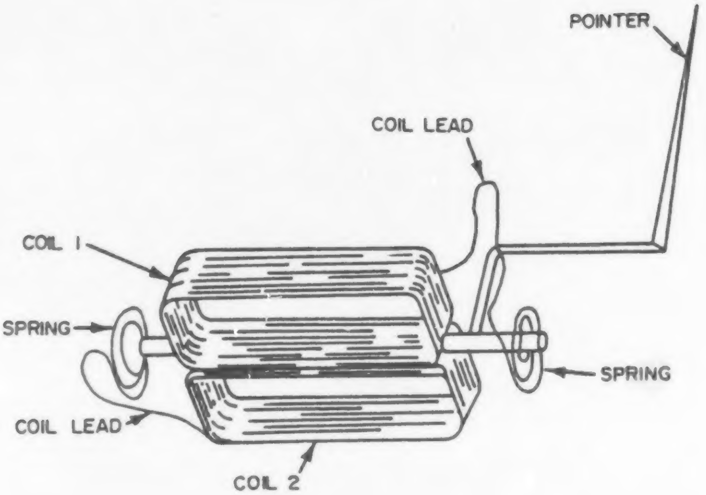
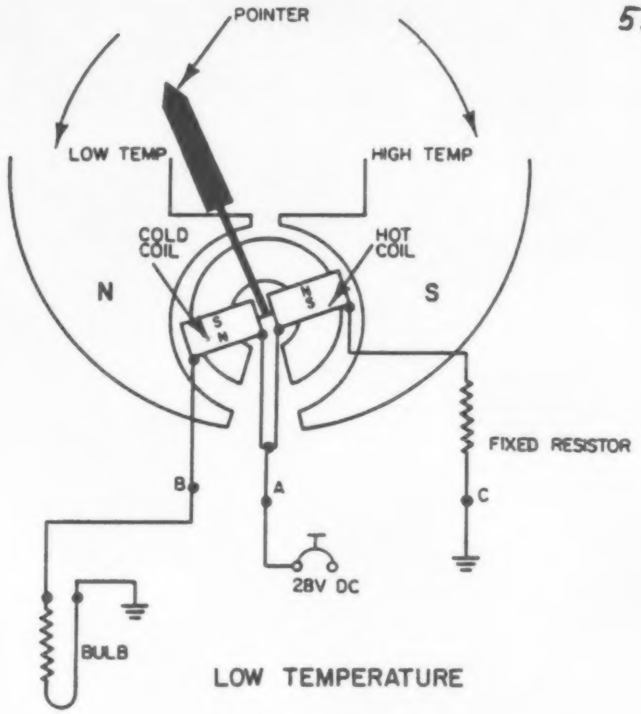
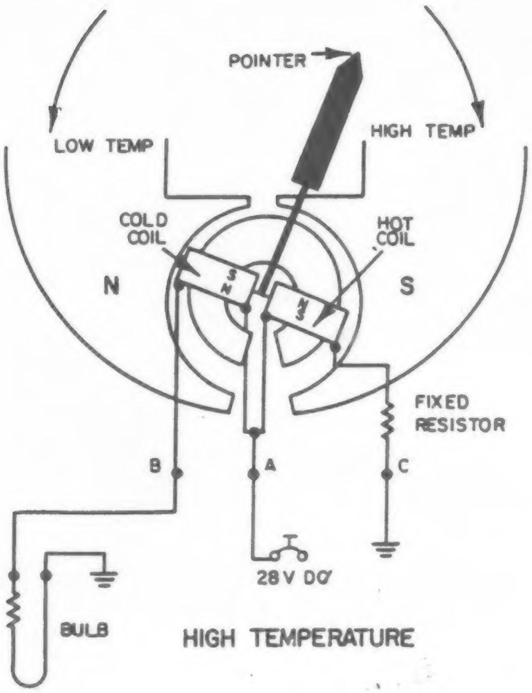

POINTER
COIL LEAD
COIL 1
SPRING
SPRING
COIL LEAD
COIL 2

Figure 40. Ratiometer Coil and Pointer Arrangement.

572


POINTER
LOW TEMP
HIGH TEMP
COLD COIL
HOT COIL
N
S
S
N
N
S
FIXED RESISTOR
B
A
C
28V DC
BULB

LOW TEMPERATURE


POINTER
LOW TEMP
HIGH TEMP
COLD COIL
HOT COIL
N
S
S
N
N
S
FIXED RESISTOR
B
A
C
28V DC
BULB

HIGH TEMPERATURE

Figure 41. Resistance Thermometer Circuit Operation.

552

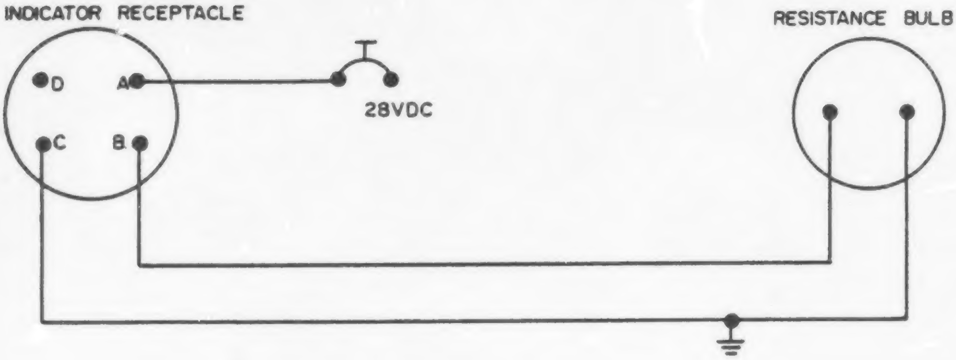

INDICATOR RECEPTACLE
D
A
C
B
28VDC
RESISTANCE BULB

Figure 42. Resistance Thermometer Wiring Schematic.

NOTES

574

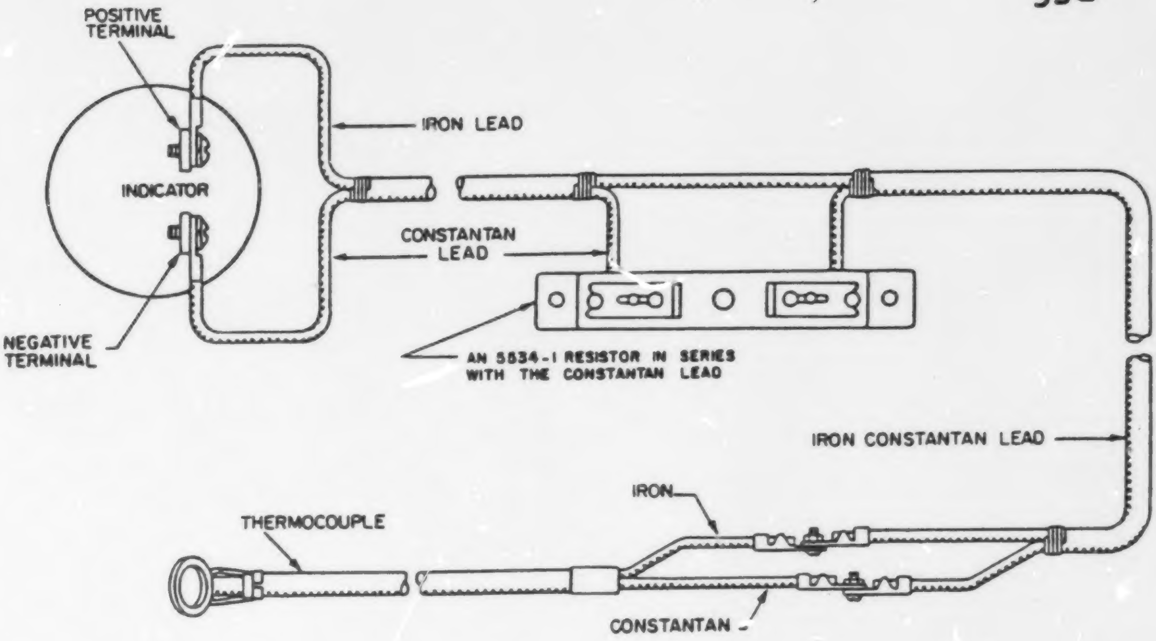

POSITIVE TERMINAL
IRON LEAD
INDICATOR
CONSTANTAN LEAD
NEGATIVE TERMINAL
AN 5534-I RESISTOR IN SERIES WITH THE CONSTANTAN LEAD
IRON CONSTANTAN LEAD
IRON
THERMOCOUPLE
CONSTANTAN

Figure 43. Cylinder Head Temperature Thermocouple System.

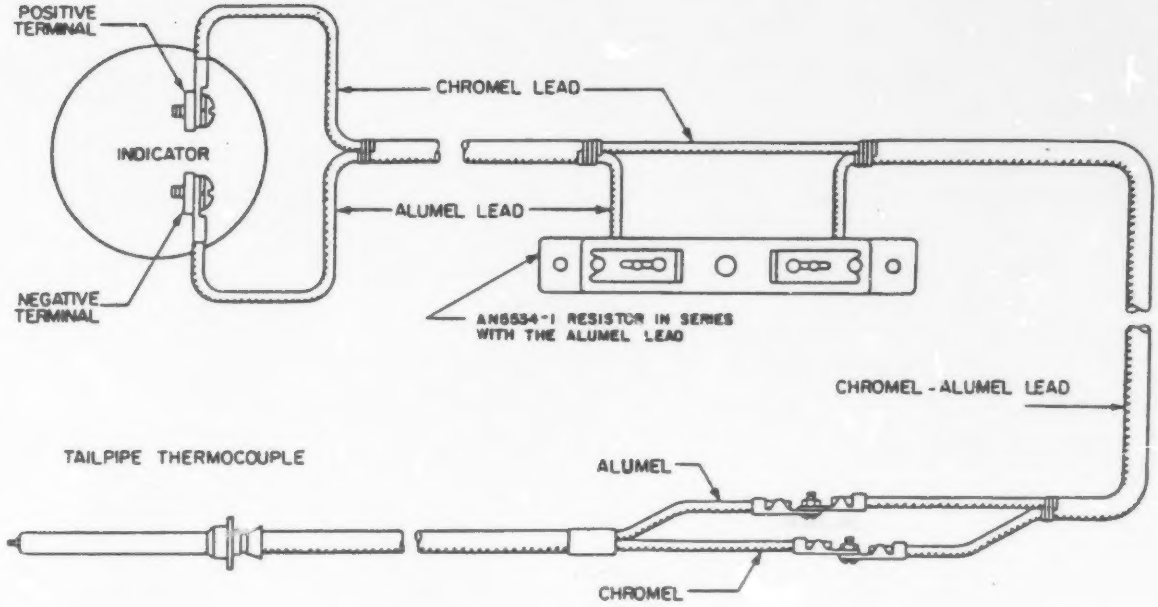

POSITIVE TERMINAL
CHROMEL LEAD
INDICATOR
ALUMEL LEAD
NEGATIVE TERMINAL
AN6534-I RESISTOR IN SERIES WITH THE ALUMEL LEAD
CHROMEL - ALUMEL LEAD
TAILPIPE THERMOCOUPLE
ALUMEL
CHROMEL

Figure 44. Exhaust Gas Temperature Thermocouple System.

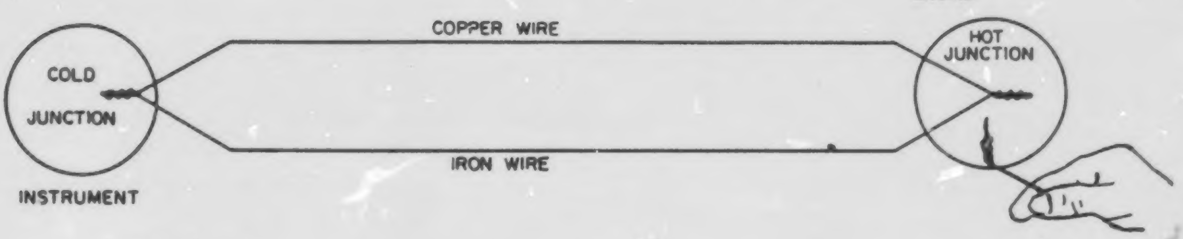
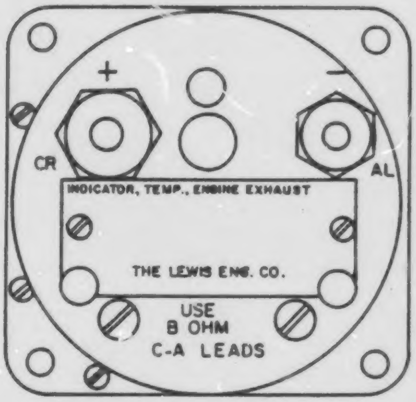
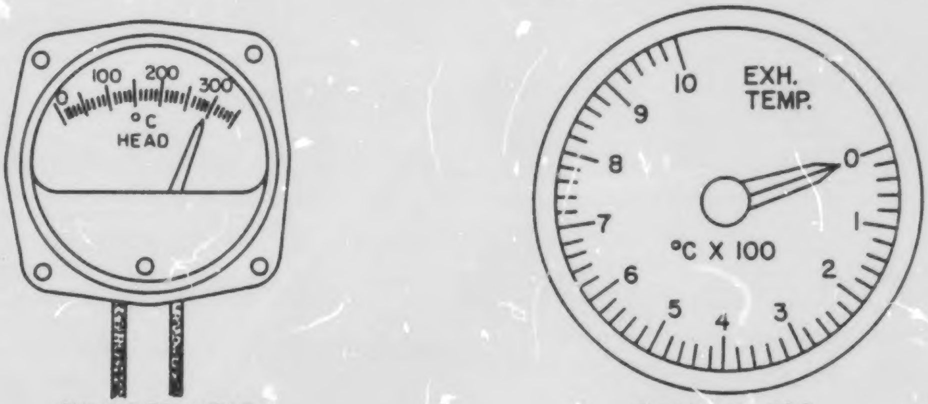

ENGINE
COPPER WIRE
HOT JUNCTION
COLD JUNCTION
IRON WIRE
INSTRUMENT

Figure 45. Thermocouple Principle of Operation.


+
−
CR
AL
INDICATOR, TEMP., ENGINE EXHAUST
THE LEWIS ENG. CO.
USE
8 OHM
C-A LEADS

BACK OF INDICATOR


0
100
200
300
°C
HEAD
10
EXH.
TEMP.
9
8
7
6
5
4
3
2
1
0
°C X 100

CYLINDER HEAD TEMPERATURE

EXHAUST GAS TEMPERATURE

Figure 46. Typical Thermocouple Indicators.

NOTES

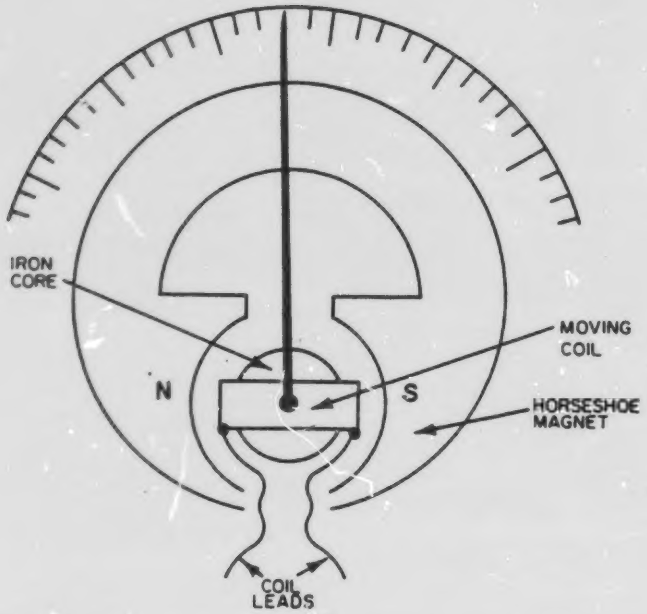

IRON CORE
MOVING COIL
N
S
HORSESHOE MAGNET
COIL LEADS

Figure 47. D'Arsonval Movement.

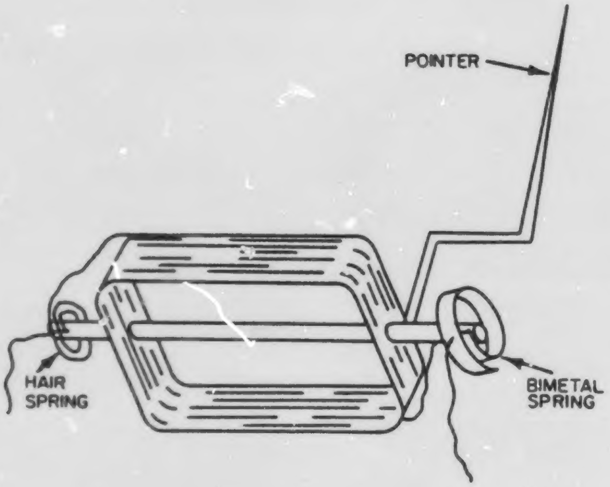

POINTER
HAIR SPRING
BIMETAL SPRING

Figure 48. D'Arsonval Coil and Pointer Arrangement.

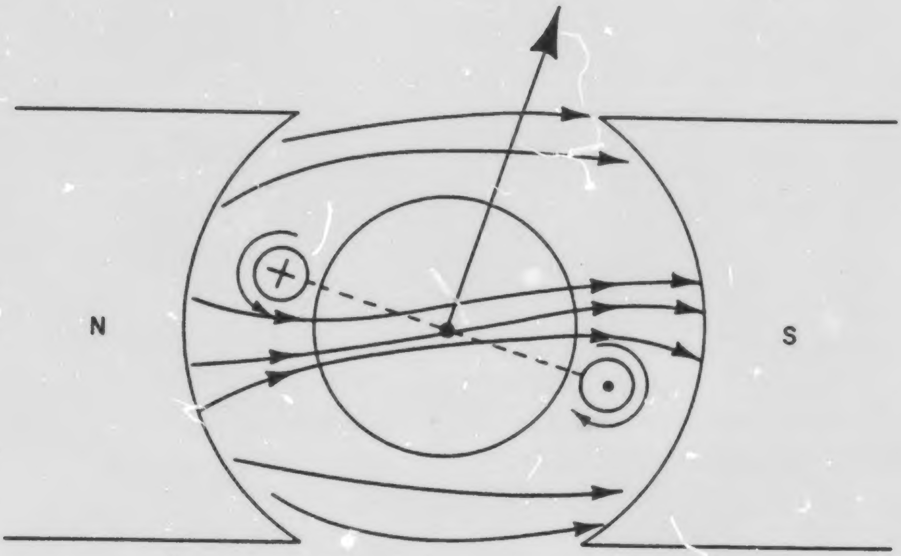


Figure 49. D'Arsonval Movement Operating Principle.

NOTES

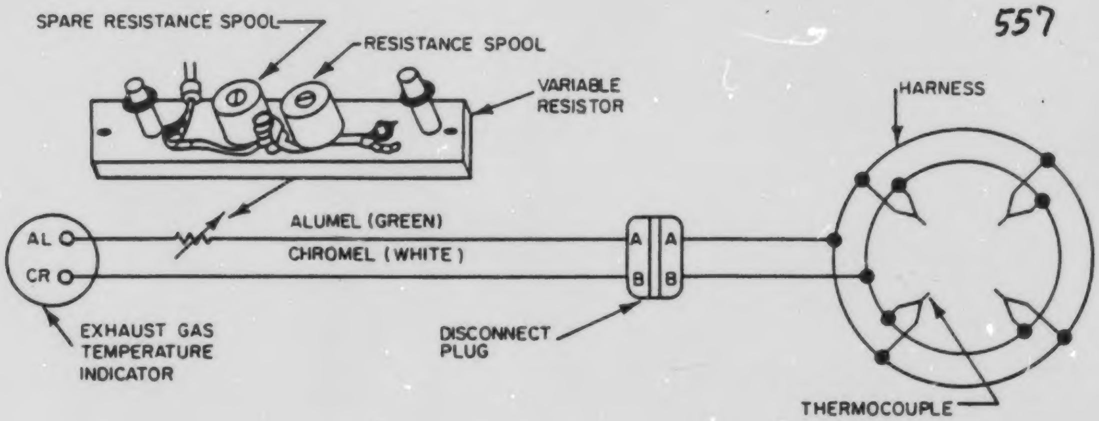

SPARE RESISTANCE SPOOL
RESISTANCE SPOOL
VARIABLE RESISTOR
HARNESS
AL
CR
ALUMEL (GREEN)
CHROMEL (WHITE)
A
B
A
B
EXHAUST GAS TEMPERATURE INDICATOR
DISCONNECT PLUG
THERMOCOUPLE

Figure 50. Wiring Schematic of Jet Engine Thermocouple System.

NOTES

FUEL FLOW INDICATING SYSTEMS

NOTES

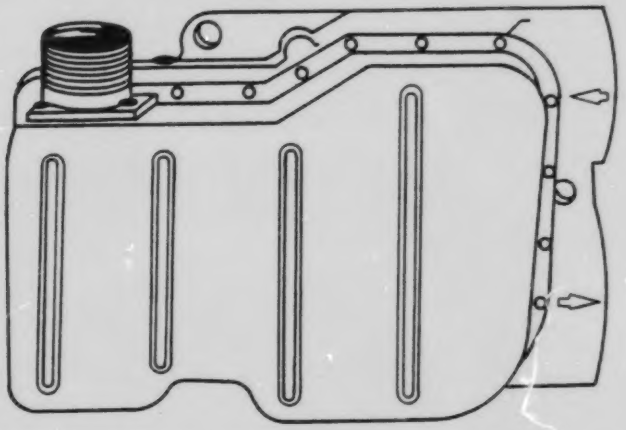


Figure 51. Fuel Flow Transmitter.

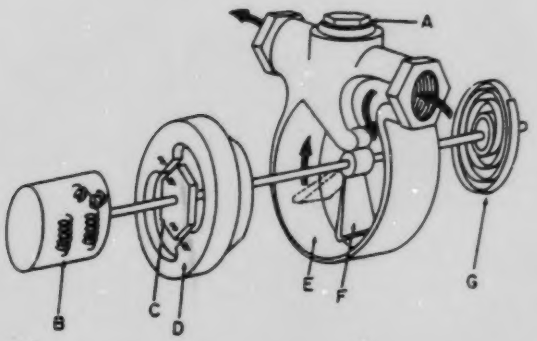
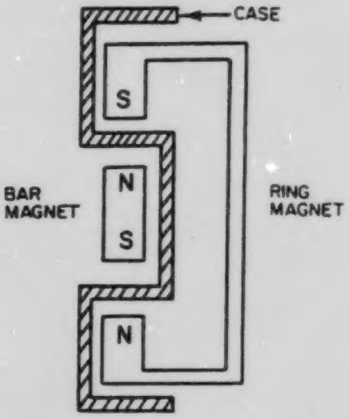


Figure 52. Moving Vane Sensing Mechanism.


CASE
S
N
S
N
BAR MAGNET
RING MAGNET

580

Figure 53. Magnetic Coupling.

NOTES

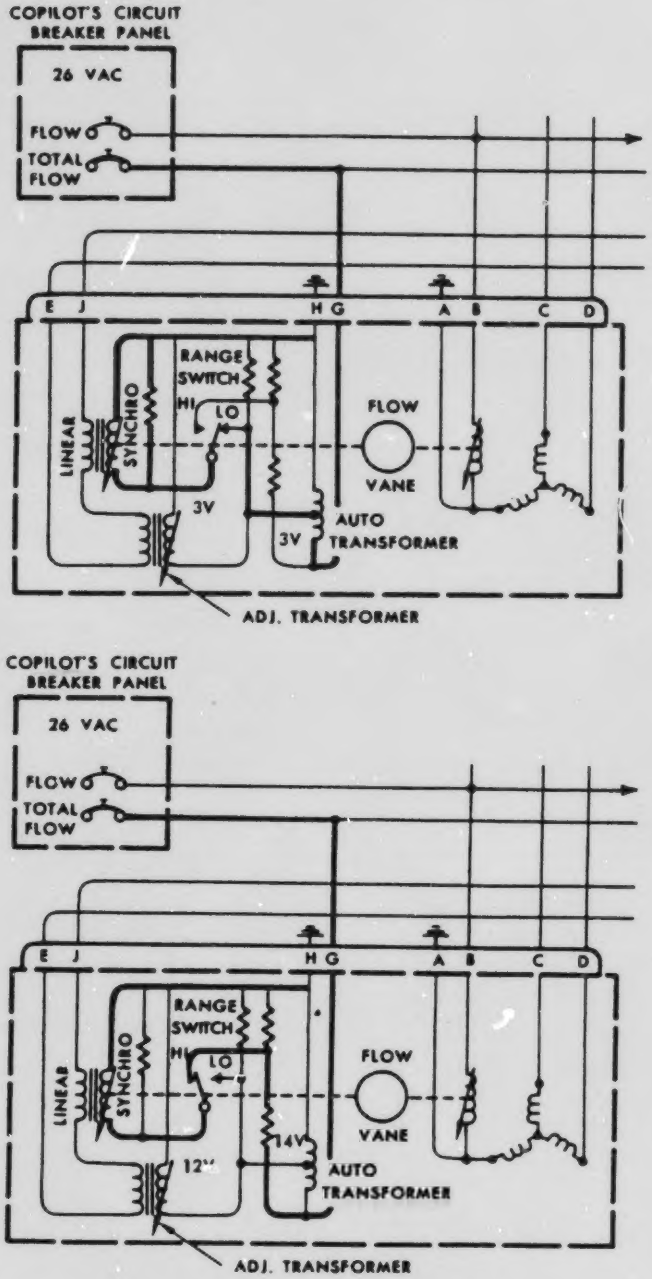

COPILOT'S CIRCUIT BREAKER PANEL
26 VAC
FLOW
TOTAL FLOW
E
J
H
G
A
B
C
D
RANGE SWITCH
HI
LO
LINEAR
SYNCHRO
FLOW
VANE
3V
3V
AUTO TRANSFORMER
ADJ. TRANSFORMER
COPILOT'S CIRCUIT BREAKER PANEL
26 VAC
FLOW
TOTAL FLOW
E
J
H
G
A
B
C
D
RANGE SWITCH
HI
LO
LINEAR
SYNCHRO
FLOW
VANE
14V
12V
AUTO TRANSFORMER
ADJ. TRANSFORMER

Figure 54. Fuel Flow Transmitter
Range Switch Operation.

560·

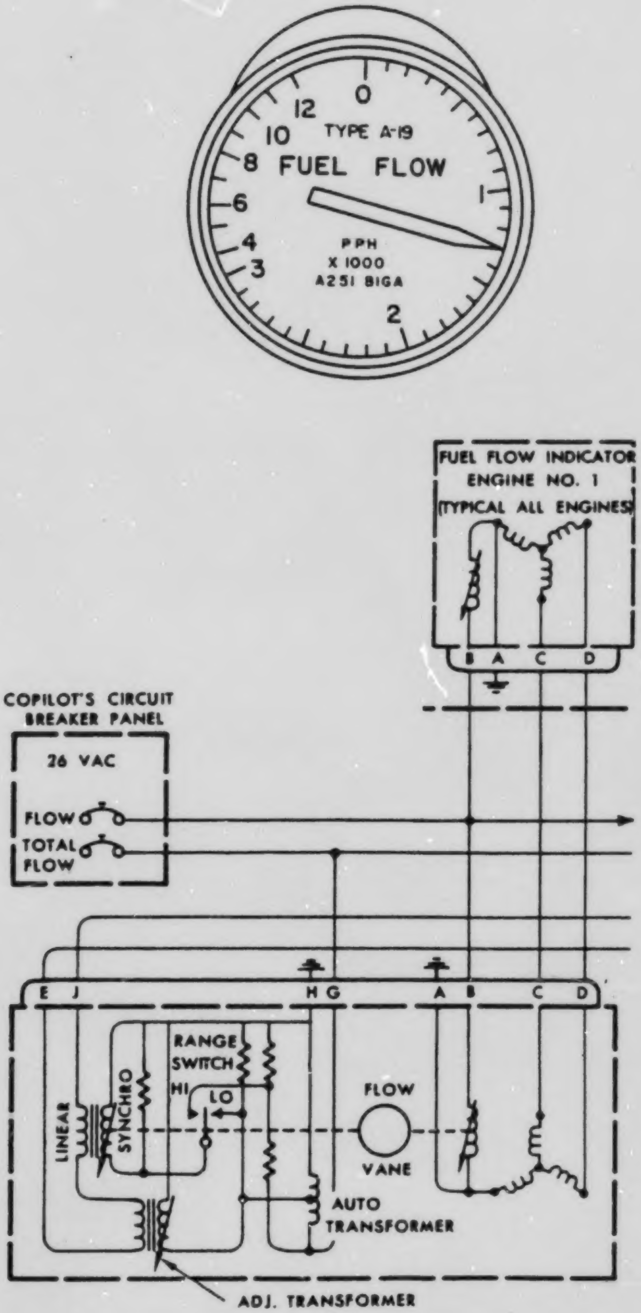

12
0
10
TYPE A-19
8
FUEL FLOW
1
6
4
3
PPH
X 1000
A251 BIGA
2
FUEL FLOW INDICATOR
ENGINE NO. 1
(TYPICAL ALL ENGINES)
B
A
C
D
COPILOT'S CIRCUIT
BREAKER PANEL
26 VAC
FLOW
TOTAL
FLOW
E
J
H
G
A
B
C
D
RANGE
SWITCH
HI
LO
LINEAR
SYNCHRO
FLOW
VANE
AUTO
TRANSFORMER
ADJ. TRANSFORMER

Figure 55. Fuel Flow Individual Indicator Operation.

582

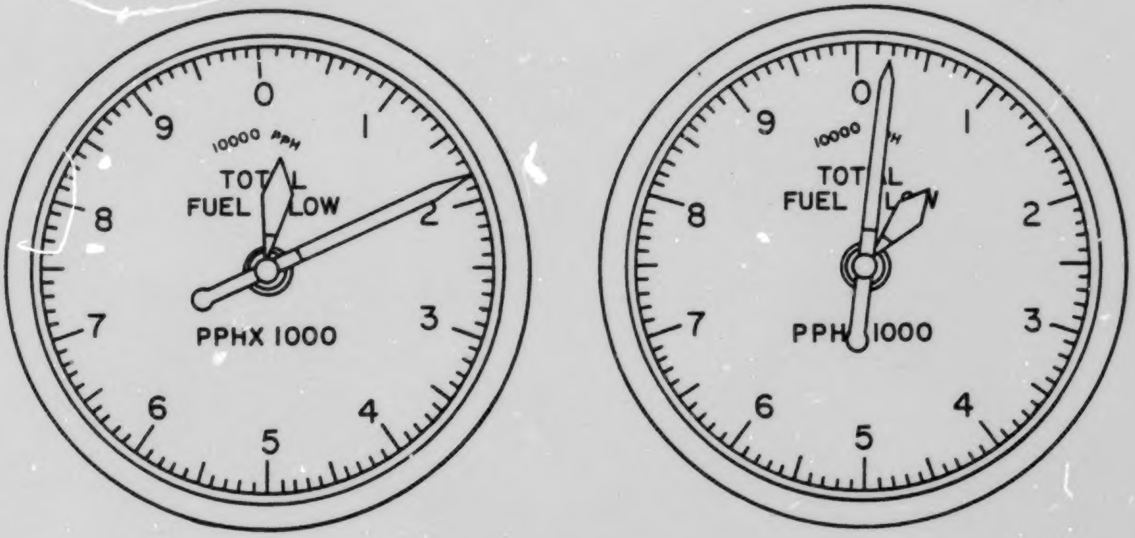

0
1
2
3
4
5
6
7
8
9
10000 PPH
TOTAL
FUEL FLOW
PPHX 1000
0
1
2
3
4
5
6
7
8
9
10000 PPH
TOTAL
FUEL FLOW
PPHX 1000

Figure 56. Fuel Flow Totalizer Indicator.

NOTES

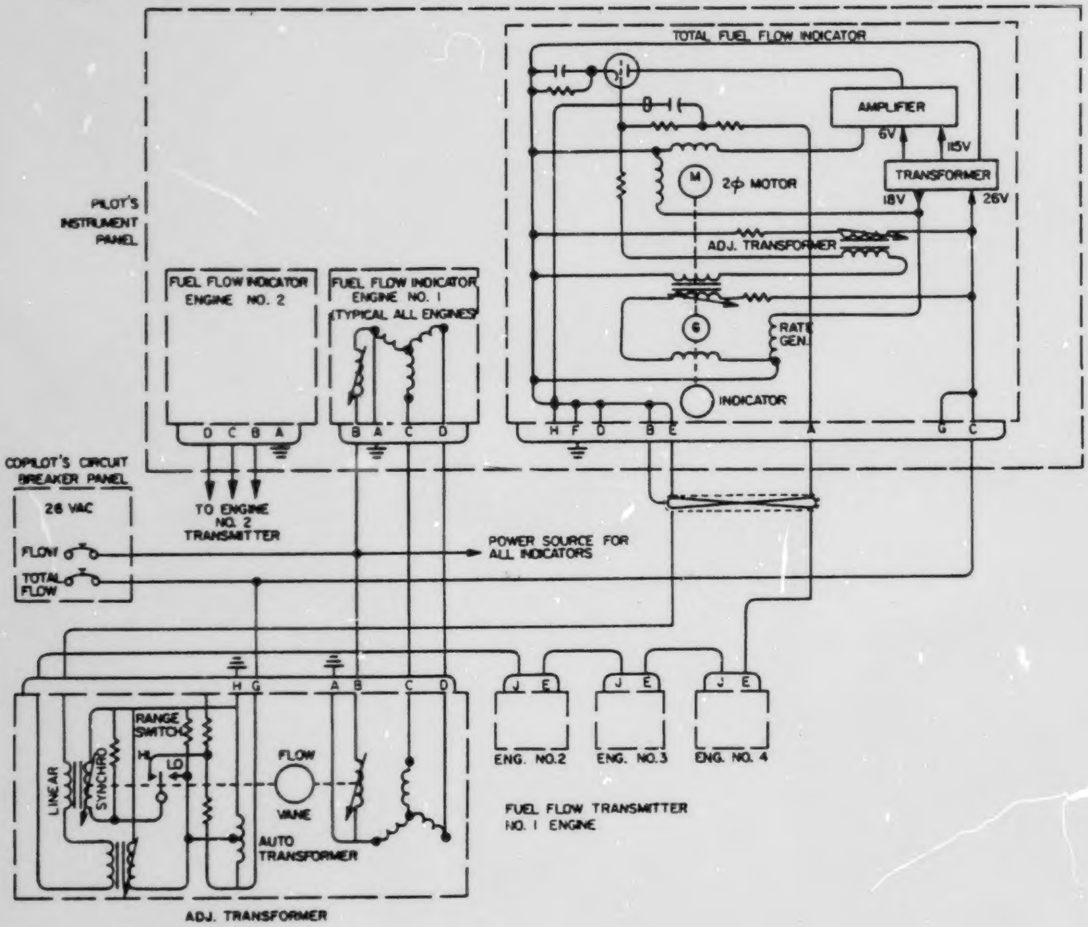

TOTAL FUEL FLOW INDICATOR
AMPLIFIER
6V
115V
TRANSFORMER
18V
26V
M
2φ MOTOR
ADJ. TRANSFORMER
G
RATE GEN.
INDICATOR
H F D B E A G C
PILOT'S INSTRUMENT PANEL
FUEL FLOW INDICATOR ENGINE NO. 2
D C B A
FUEL FLOW INDICATOR ENGINE NO. 1 (TYPICAL ALL ENGINES)
B A C D
COPILOT'S CIRCUIT BREAKER PANEL
28 VAC
FLOW
TOTAL FLOW
TO ENGINE NO. 2 TRANSMITTER
POWER SOURCE FOR ALL INDICATORS
H G A B C D
J E
ENG. NO.2
ENG. NO.3
ENG. NO. 4
RANGE SWITCH
HI
LO
LINEAR
SYNCHRO
FLOW
VANE
AUTO TRANSFORMER
FUEL FLOW TRANSMITTER NO. 1 ENGINE
ADJ. TRANSFORMER

Figure 57. Fuel Flow Indicating System Wiring Schematic.

NOTES

563

ENGINE PRESSURE RATIO INDICATING SYSTEMS

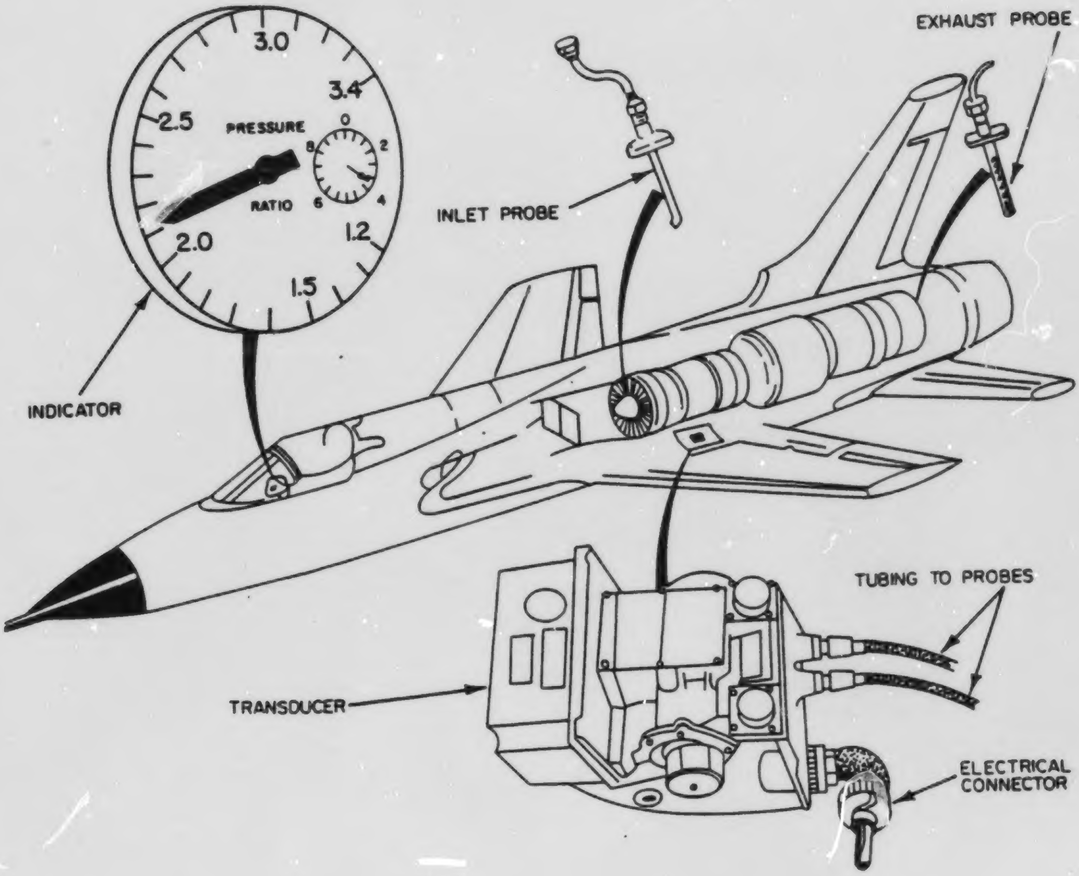

3.0
3.4
2.5
PRESSURE
RATIO
0
2
4
6
8
1.2
2.0
1.5
INDICATOR
INLET PROBE
EXHAUST PROBE
TUBING TO PROBES
TRANSDUCER
ELECTRICAL CONNECTOR

Figure 58. Typical Engine Pressure Ratio Indicating System.

NOTES

585

NOTES

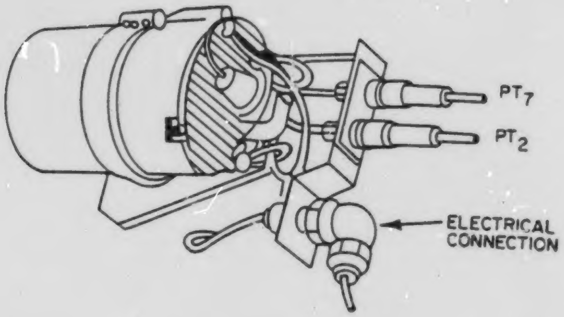

PT_7
PT_2
ELECTRICAL CONNECTION

Figure 59. Engine Pressure Ratio Transducer.

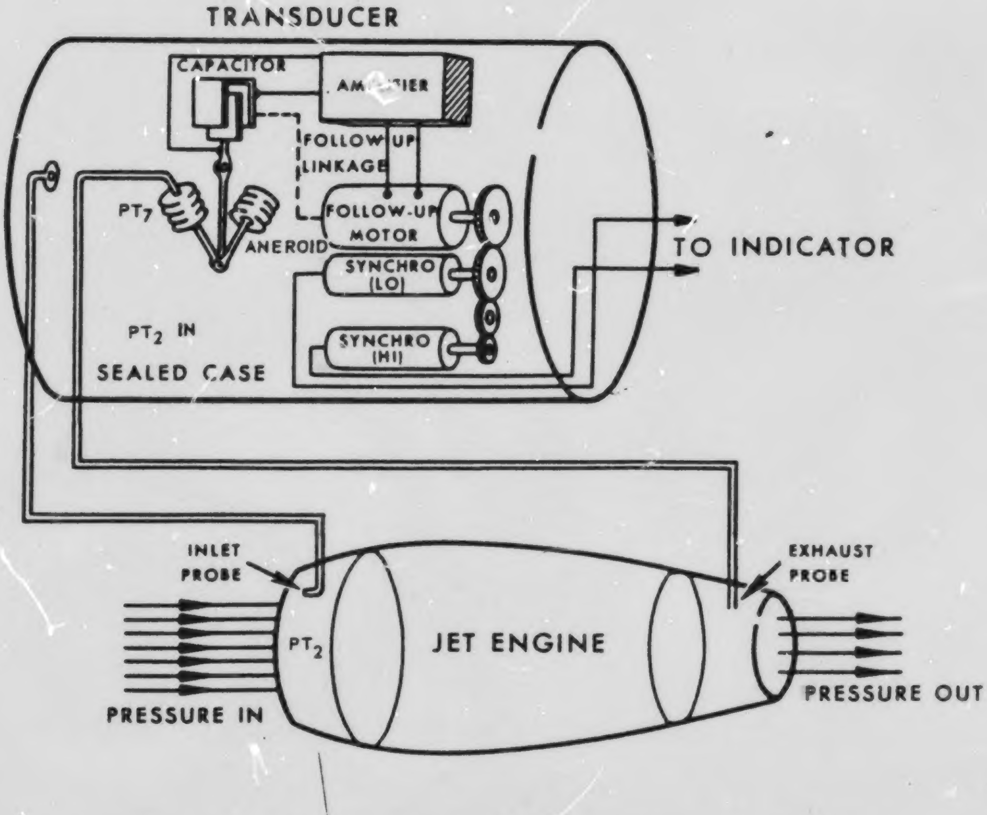

TRANSDUCER
CAPACITOR
AMPLIFIER
FOLLOW-UP LINKAGE
PT_7
FOLLOW-UP MOTOR
ANEROID
SYNCHRO (LO)
SYNCHRO (HI)
TO INDICATOR
PT_2 IN
SEALED CASE
INLET PROBE
EXHAUST PROBE
PT_2
JET ENGINE
PRESSURE IN
PRESSURE OUT

Figure 60. Minneapolis-Honeywell Engine Pressure Ratio Transducer Operation.

NOTES

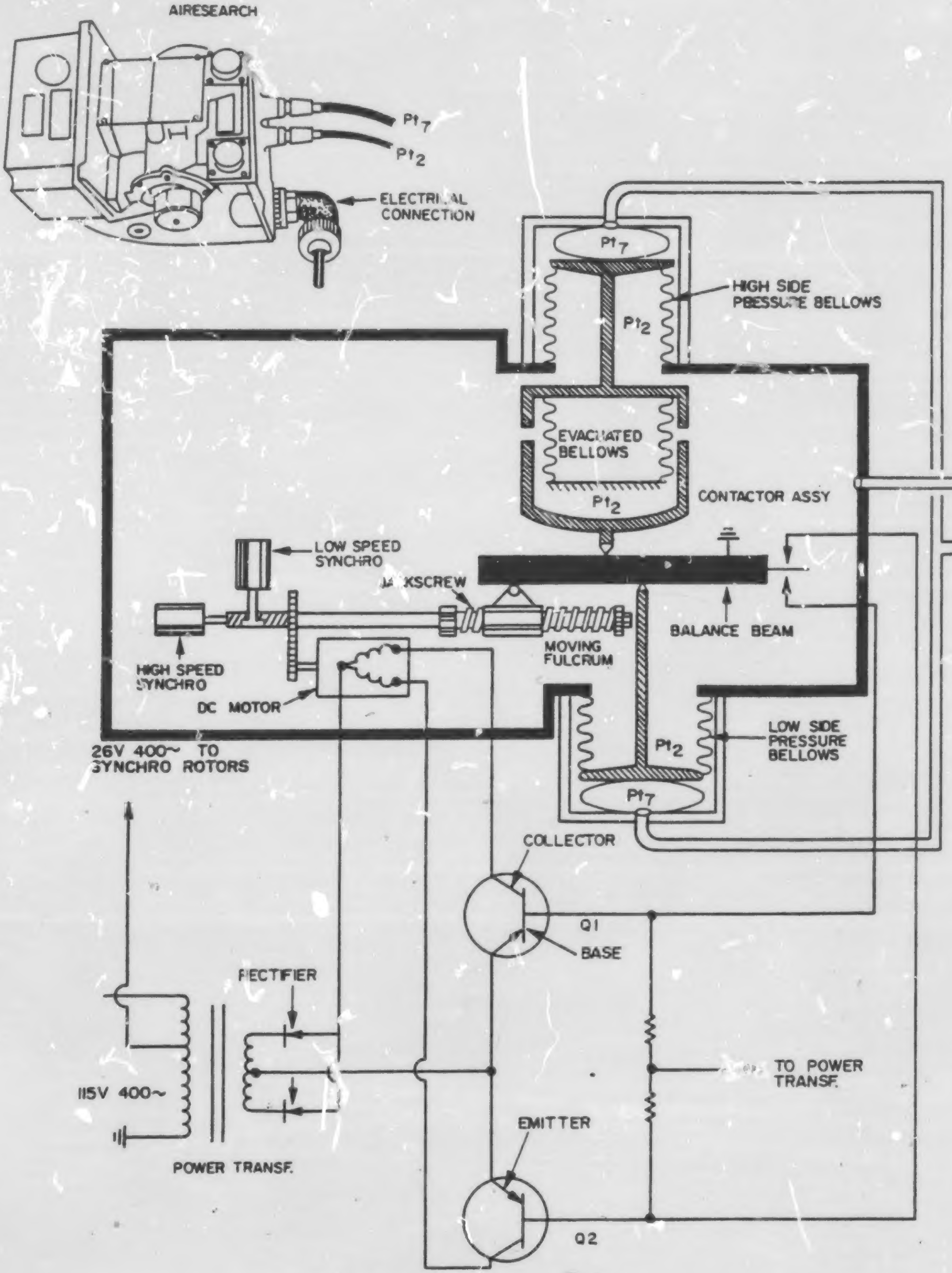

AIRESEARCH
Pt7
Pt2
ELECTRICAL CONNECTION
Pt7
HIGH SIDE PRESSURE BELLOWS
Pt2
EVACUATED BELLOWS
Pt2
CONTACTOR ASSY
Pt2
Pt7
LOW SPEED SYNCHRO
JACKSCREW
BALANCE BEAM
MOVING FULCRUM
HIGH SPEED SYNCHRO
DC MOTOR
Pt2
LOW SIDE PRESSURE BELLOWS
Pt7
26V 400~ TO SYNCHRO ROTORS
COLLECTOR
Q1
BASE
RECTIFIER
115V 400~
TO POWER TRANSF.
POWER TRANSF.
EMITTER
Q2

Figure 61. Airsearch EPR Transducer.

NOTES

568

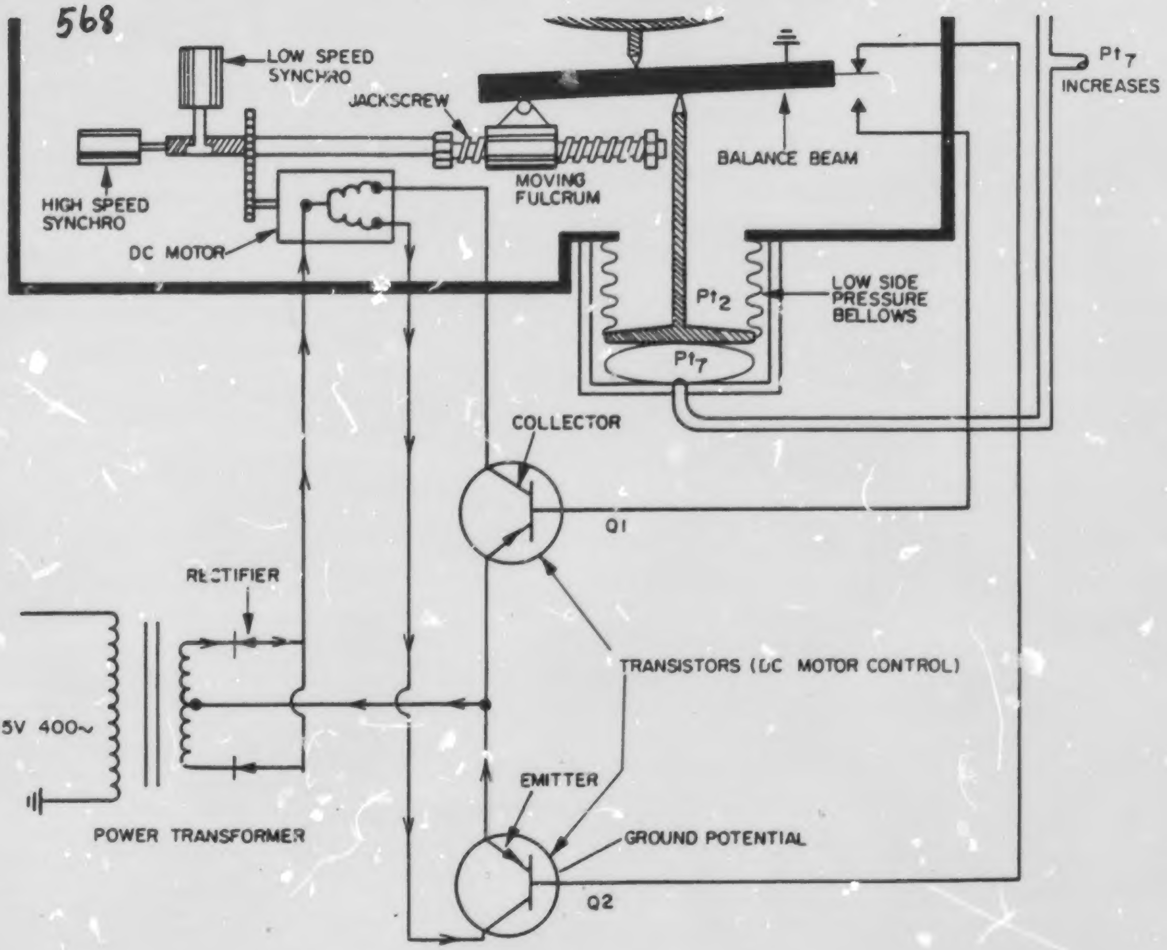

LOW SPEED SYNCHRO
JACKSCREW
HIGH SPEED SYNCHRO
DC MOTOR
MOVING FULCRUM
BALANCE BEAM
Pt7 INCREASES
Pt2
Pt7
LOW SIDE PRESSURE BELLOWS
COLLECTOR
Q1
RECTIFIER
TRANSISTORS (DC MOTOR CONTROL)
115V 400~
POWER TRANSFORMER
EMITTER
GROUND POTENTIAL
Q2

Figure 62. AiResearch Transducer Operation with PT$_7$ Increase.

NOTES

530

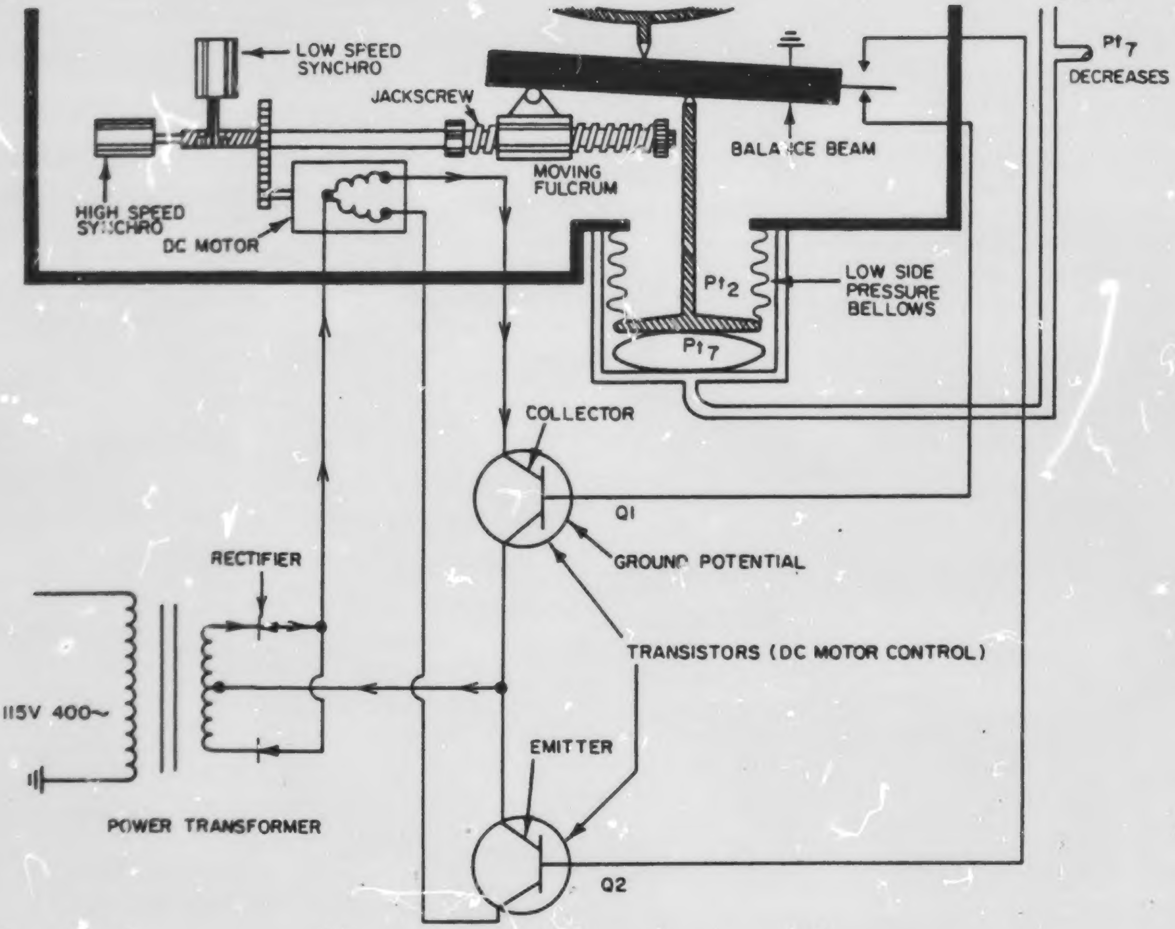

LOW SPEED SYNCHRO
JACKSCREW
HIGH SPEED SYNCHRO
DC MOTOR
MOVING FULCRUM
BALANCE BEAM
Pt_7 DECREASES
Pt_2
LOW SIDE PRESSURE BELLOWS
Pt_7
COLLECTOR
Q1
GROUND POTENTIAL
RECTIFIER
TRANSISTORS (DC MOTOR CONTROL)
115V 400~
EMITTER
POWER TRANSFORMER
Q2

Figure 63. AiResearch Transducer Operation with PT_7 Decrease.

NOTES

570

NOTES

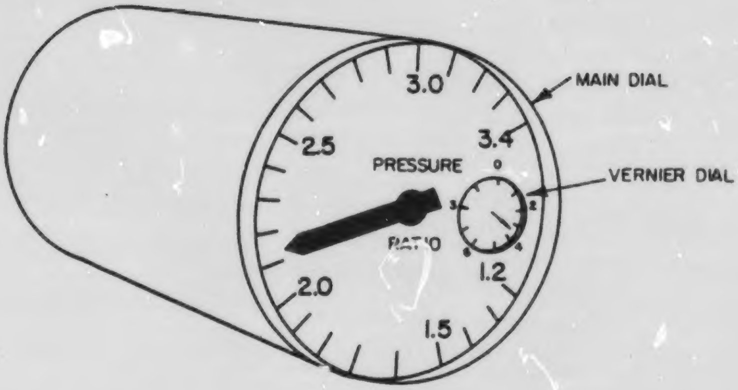

3.0
3.4
2.5
PRESSURE
RATIO
2.0
1.5
1.2
0
2
4
6
8
MAIN DIAL
VERNIER DIAL

Figure 64. Engine Pressure Ratio Indicator.

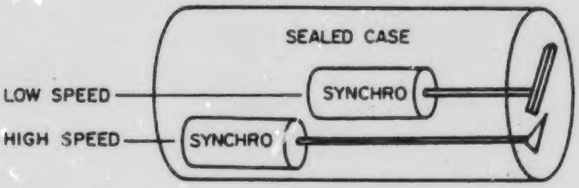

SEALED CASE
LOW SPEED
SYNCHRO
HIGH SPEED
SYNCHRO

Figure 65. Engine Pressure Ratio Indicator Internal Schematic.

592

UNIT 207

RESISTANCE-TYPE LIQUID QUANTITY SYSTEM

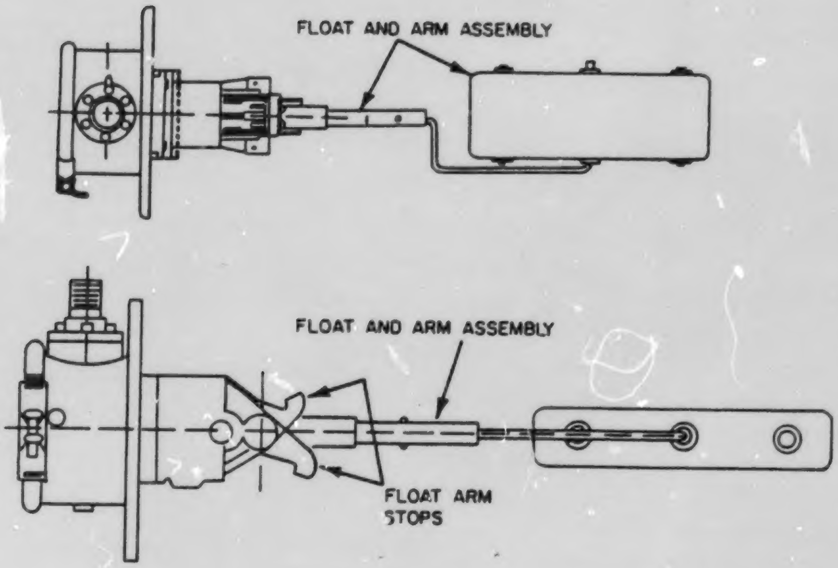

FLOAT AND ARM ASSEMBLY
FLOAT AND ARM ASSEMBLY
FLOAT ARM STOPS

Figure 66. Float-Type Liquid Level Transmitter.

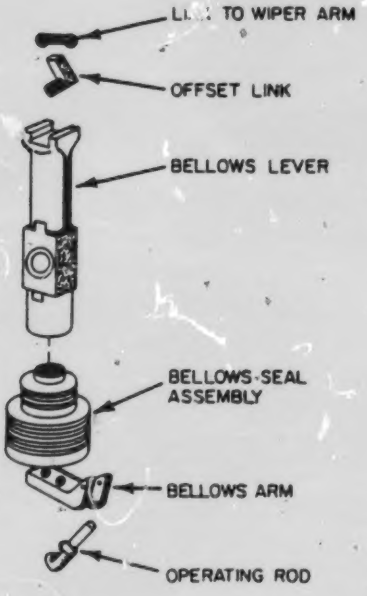

LINK TO WIPER ARM
OFFSET LINK
BELLOWS LEVER
BELLOWS-SEAL ASSEMBLY
BELLOWS ARM
OPERATING ROD

Figure 67. Bellows and Linkage Assembly.

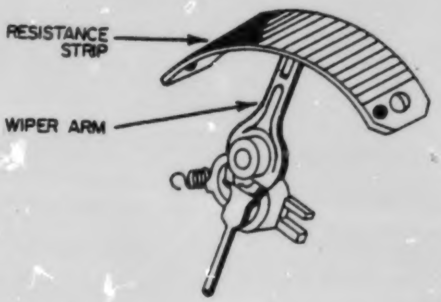

RESISTANCE STRIP
WIPER ARM

Figure 68. Wiper Arm Assembly.

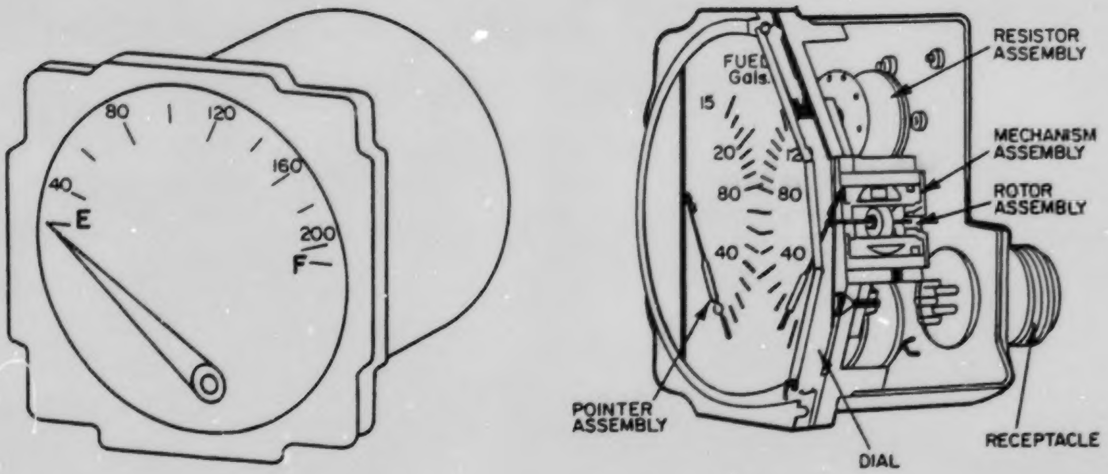

80
120
160
40
E
200
F
FUEL
Gals.
15
20
12
80
80
40
40
RESISTOR ASSEMBLY
MECHANISM ASSEMBLY
ROTOR ASSEMBLY
POINTER ASSEMBLY
DIAL
RECEPTACLE

Figure 69. Resistance Liquid Level Indicator.

NOTES

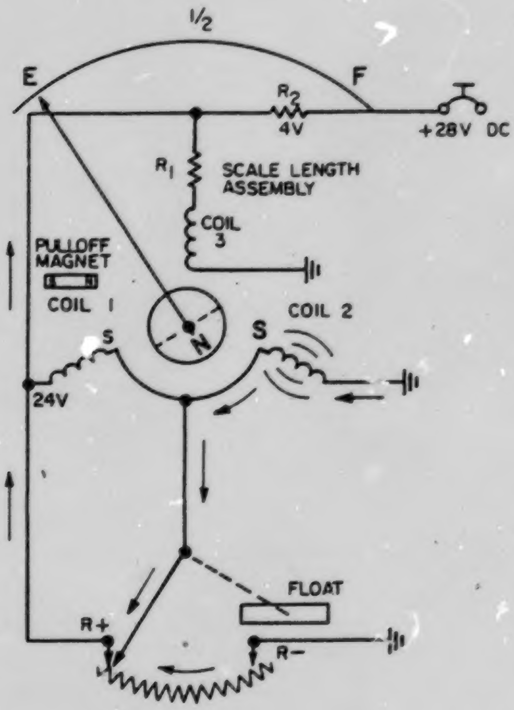

1/2
E
F
R_2
4V
+28V DC
R_1
SCALE LENGTH ASSEMBLY
COIL 3
PULLOFF MAGNET
COIL 1
S
N
S
COIL 2
24V
FLOAT
R+
R−

Figure 70. Resistance Liquid Level System Operation.

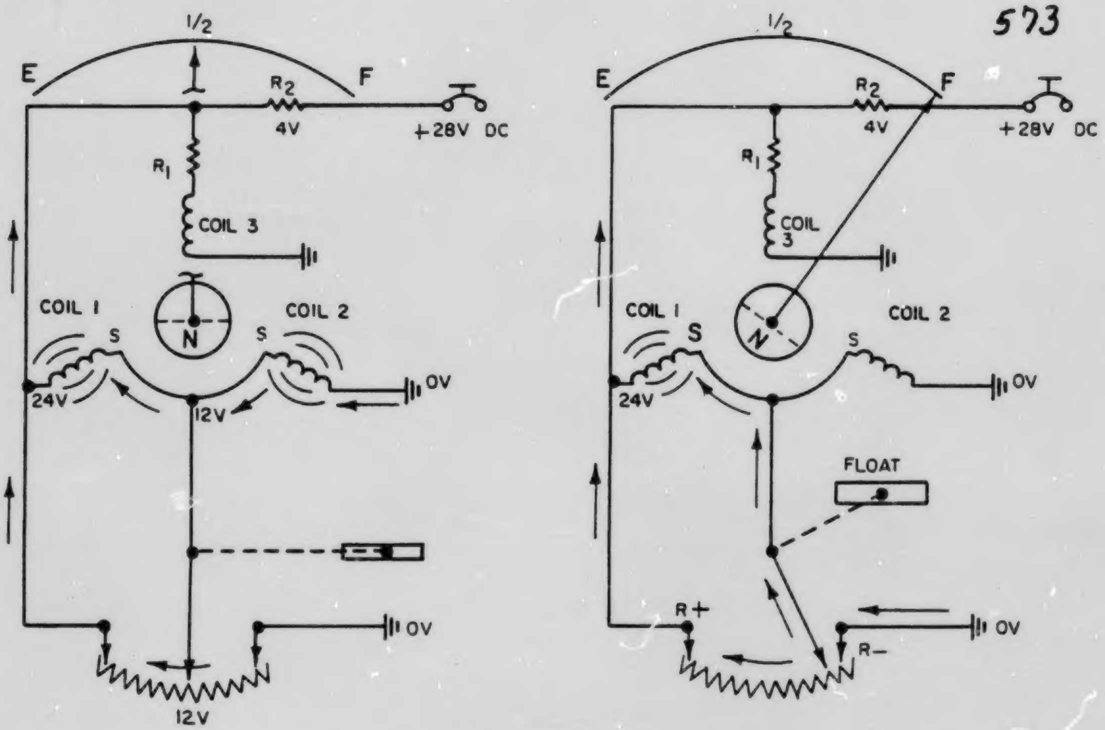

1/2
E
F
R2
4V
+28V DC
R1
COIL 3
COIL 1
COIL 2
S
S
N
24V
12V
OV
OV
12V
1/2
E
F
R2
4V
+28V DC
R1
COIL 3
COIL 1
COIL 2
S
S
N
24V
OV
FLOAT
R+
R-
OV

Figure 71. Resistance Liquid Level System Operation (Continued).

NOTES

UNIT 208

CAPACITANCE LIQUID QUANTITY SYSTEM

$$C = \frac{A\,K}{D}$$

C = Capacitance
A = Area of Plates
K = Dielectric
D = Distance between Plates

VACUUM	1.00000
AIR	1.00059
115/145 GRADE AVIATION GASOLINE	1.971
JP-4 FUEL	2.083
MICA	5.7 to 7.0
WATER	81.7

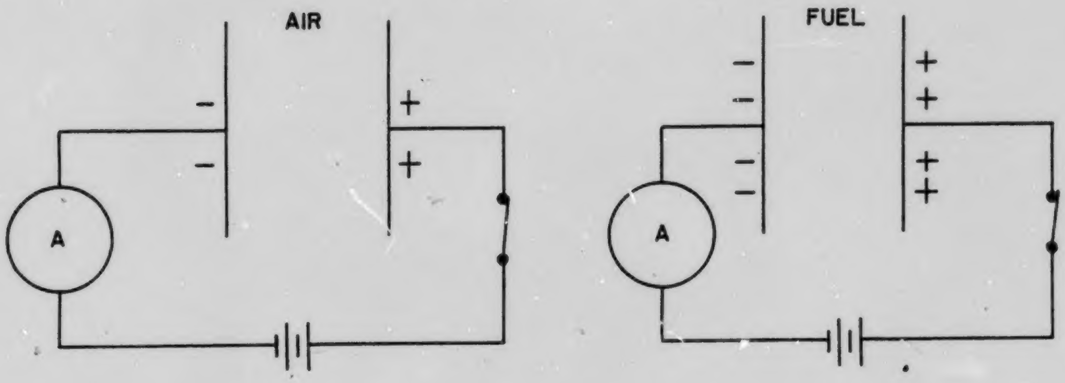
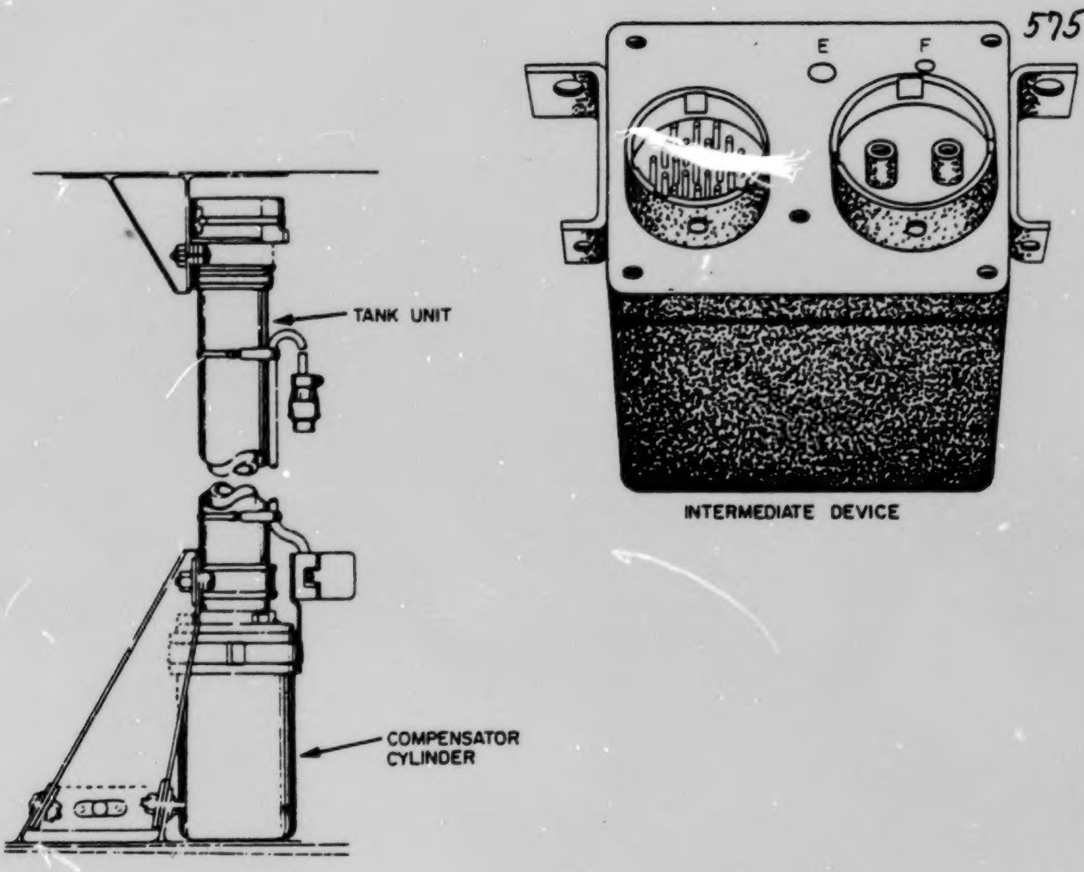
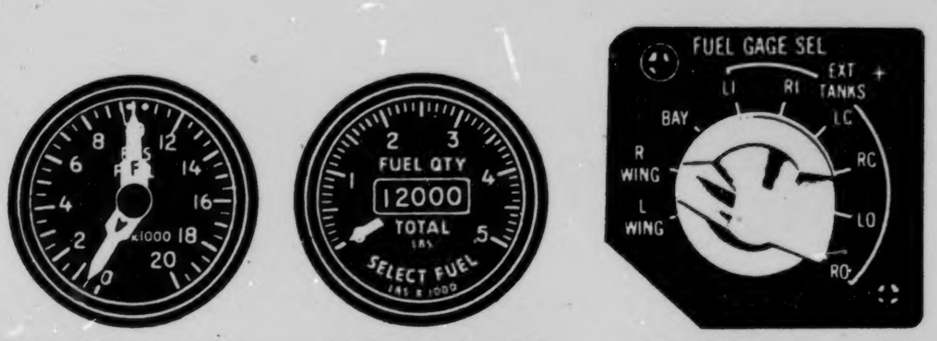


Figure 72. Capacitor Characteristics.


E
F
TANK UNIT
COMPENSATOR CYLINDER

INTERMEDIATE DEVICE

TANK UNIT AND COMPENSATOR


8
10
12
6
14
4
16
2
18
0
20
LBS
FUEL
X1000
2
3
1
4
5
FUEL QTY
12000
TOTAL
LBS
SELECT FUEL
LBS X 1000
FUEL GAGE SEL
LI
RI
EXT TANKS
BAY
LC
R WING
RC
L WING
LO
RO

FUSELAGE FUEL INDICATOR

SELECT AND TOTALIZER FUEL INDICATOR

FUEL GAGE SELECT SWITCH

Figure 73. Capacitance Fuel Quantity Indicating System Components.

576

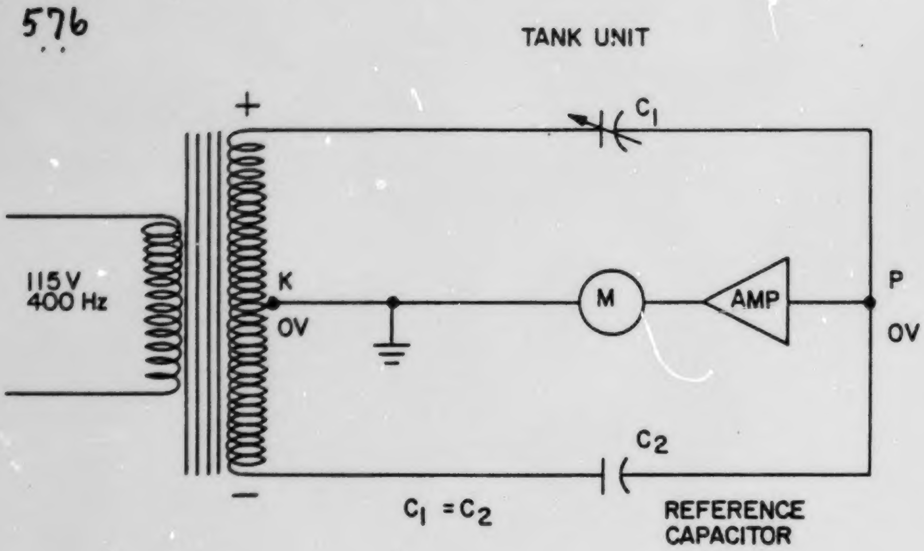

TANK UNIT
+
C1
115V
400 Hz
K
0V
M
AMP
P
0V
C2
−
C1 = C2
REFERENCE
CAPACITOR

Figure 74. Capacitance Fuel Quantity Indicating System (Basic Bridge Circuit).

NOTES

598

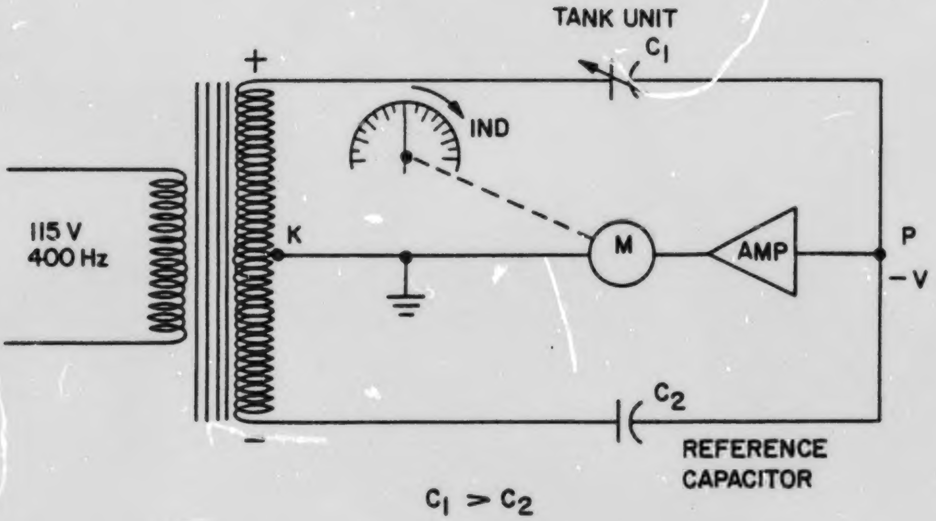

TANK UNIT
C_1
+
IND
115 V
400 Hz
K
M
AMP
P
−V
C_2
−
REFERENCE
CAPACITOR
$C_1 > C_2$

Figure 75. Capacitance Fuel Quantity Indicating System (Fuel Level Increasing).

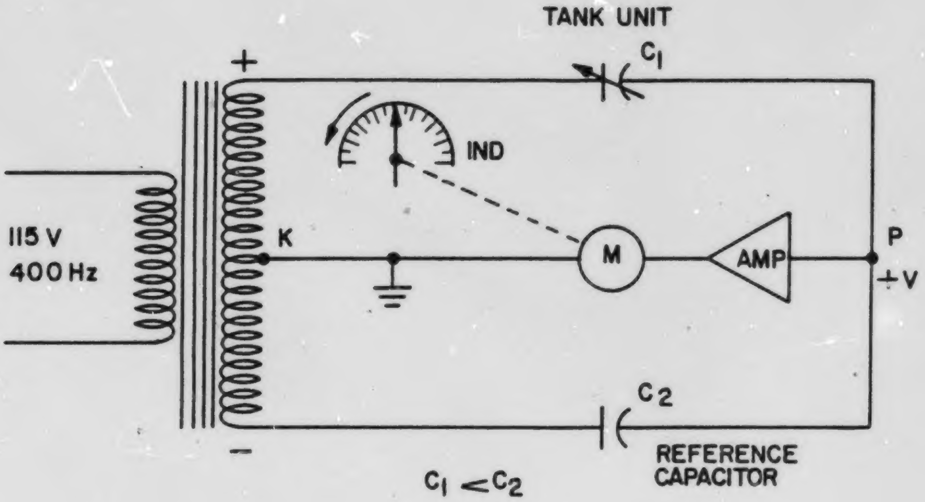

TANK UNIT
C_1
+
IND
115 V
400 Hz
K
M
AMP
P
+V
C_2
−
REFERENCE
CAPACITOR
$C_1 < C_2$

Figure 76. Capacitance Fuel Quantity Indicating System (Fuel Level Decreasing).

578

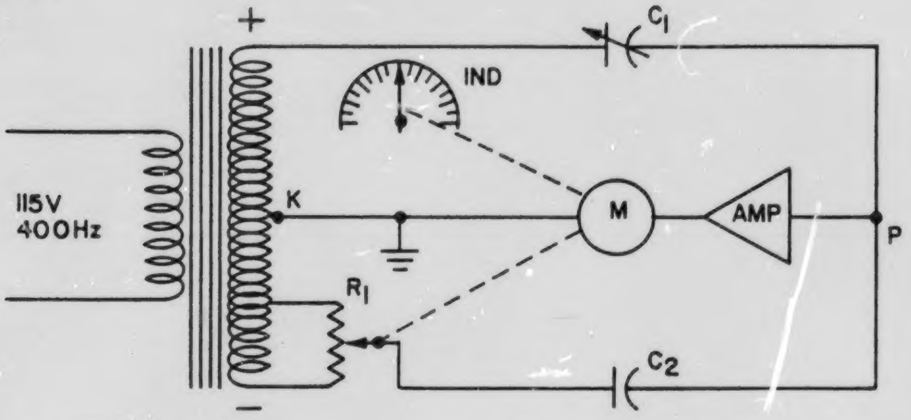

+
C₁
IND
115V
400Hz
K
M
AMP
P
R₁
C₂
−

Figure 77. Capacitance Fuel Quantity Indicating System (Rebalance Potentiometer Added).

NOTES

600

579

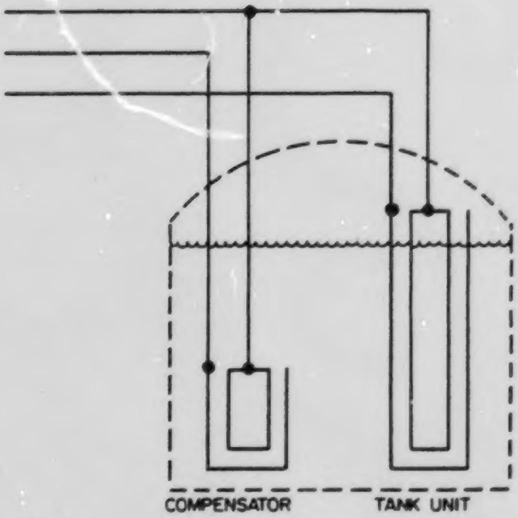

COMPENSATOR
TANK UNIT

Figure 78. Capacitance Fuel Quantity System Compensator.

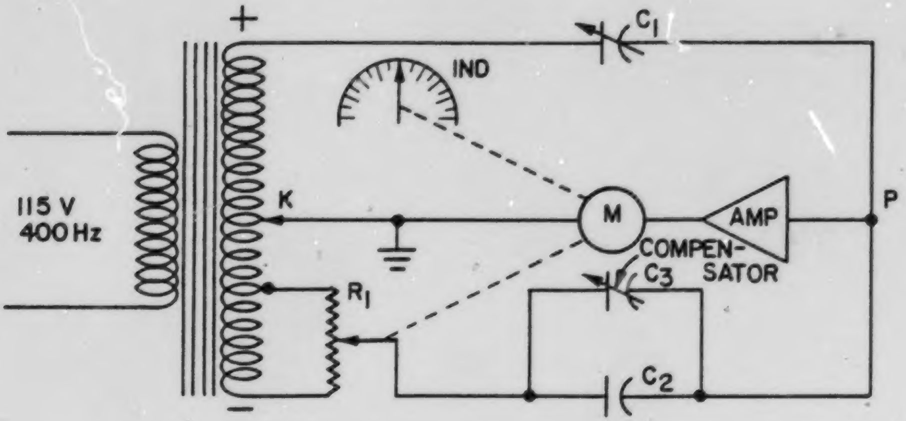

+
C1
IND
115 V
400 Hz
K
M
AMP
P
COMPEN-
SATOR
C3
R1
C2
−

Figure 79. Capacitor Fuel Quantity Indicating System (Compensator Added).

NOTES

601

580

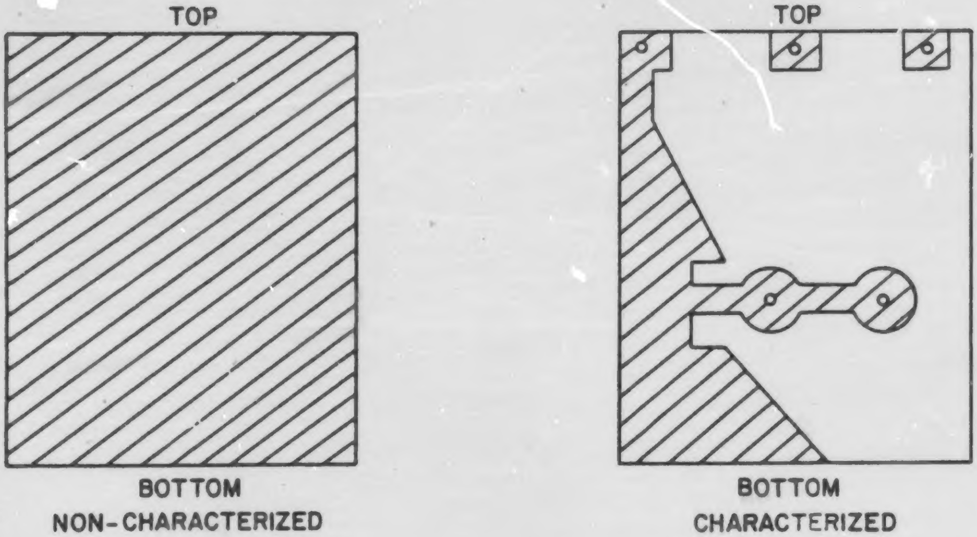

TOP
BOTTOM
NON-CHARACTERIZED
TOP
BOTTOM
CHARACTERIZED

Figure 80. Characterized Tank Unit.

NOTES

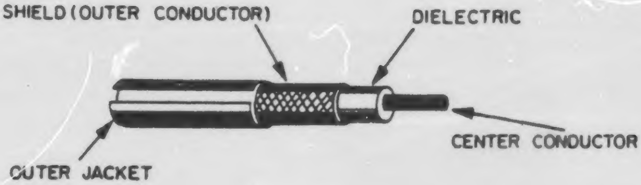

SHIELD (OUTER CONDUCTOR)
DIELECTRIC
CENTER CONDUCTOR
OUTER JACKET

Figure 81. Co-Axial Cable (COAX).

602

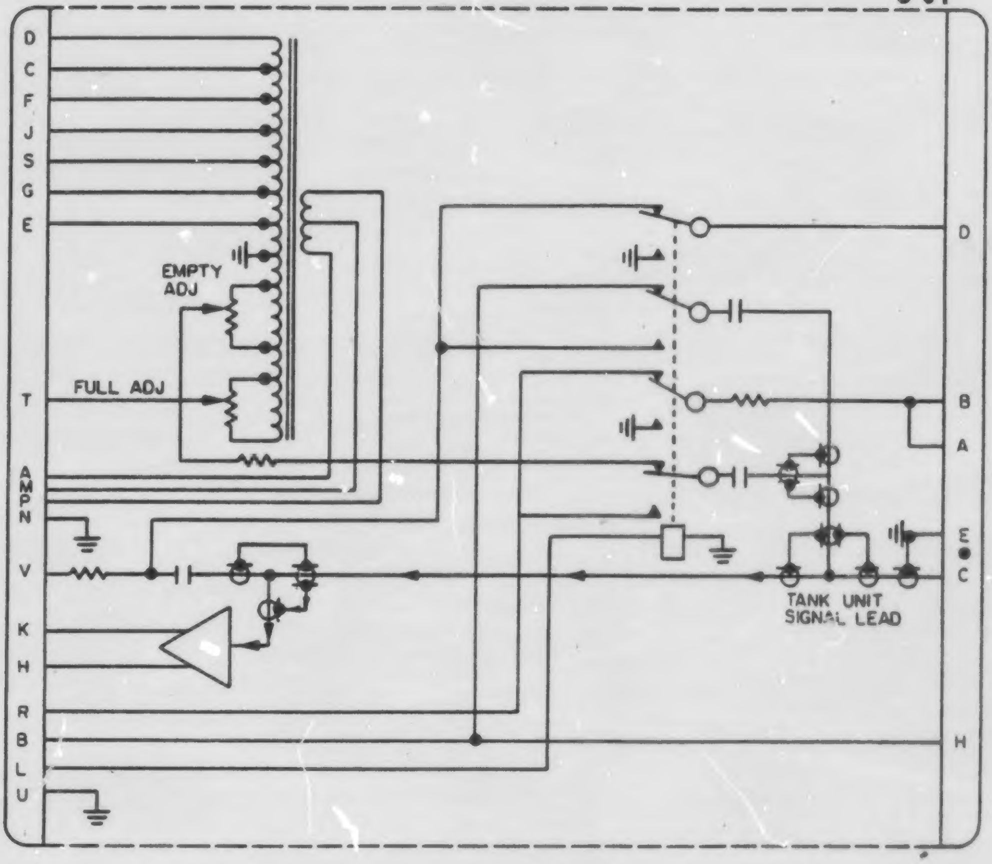

D
C
F
J
S
G
E
EMPTY ADJ
FULL ADJ
T
A
M
P
N
V
K
H
R
B
L
U
D
B
A
E
C
TANK UNIT SIGNAL LEAD
H

Figure 82. Intermediate Device Wiring Schematic.

NOTES

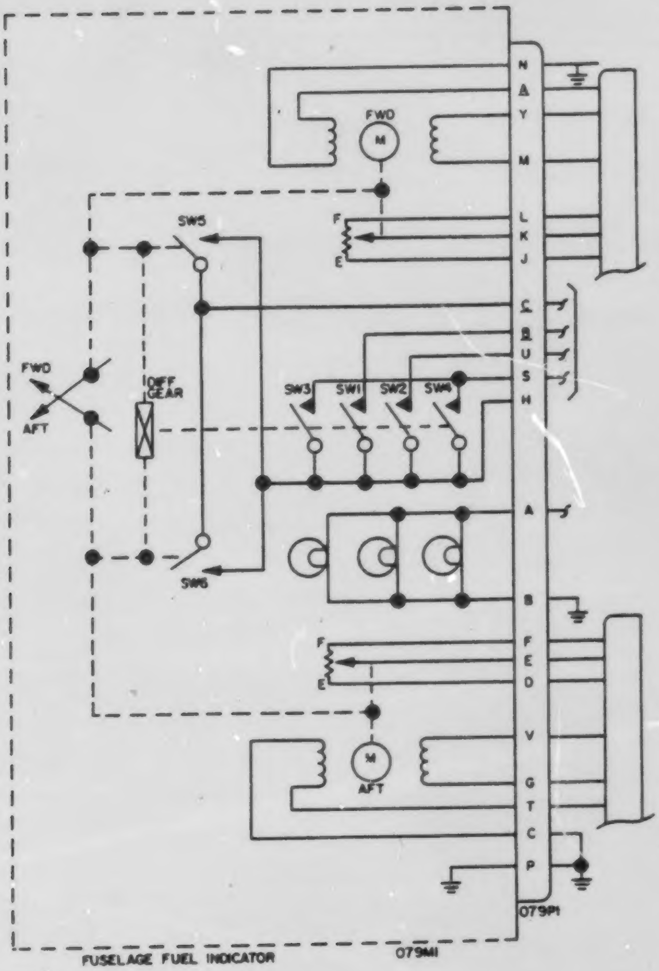

N
A
Y
M
FWD
M
L
K
J
F
E
SW5
C
B
U
S
H
FWD
AFT
DIFF GEAR
SW3
SW1
SW2
SW4
A
SW6
B
F
E
D
F
E
V
M
AFT
G
T
C
P
079P1
FUSELAGE FUEL INDICATOR
079M1

Figure 83. Fuselage Indicator Wiring Schematic.

NOTES

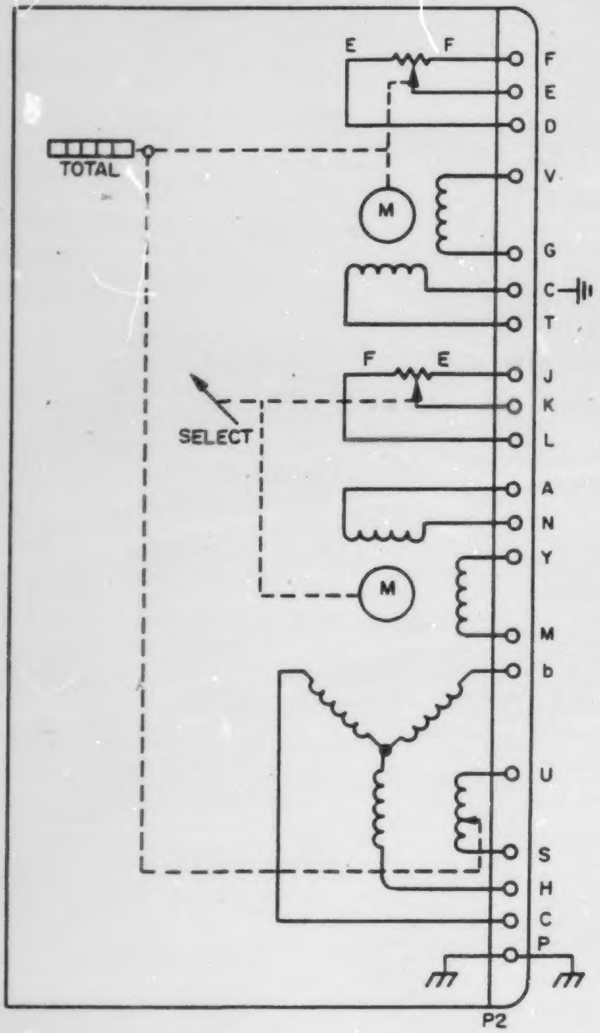
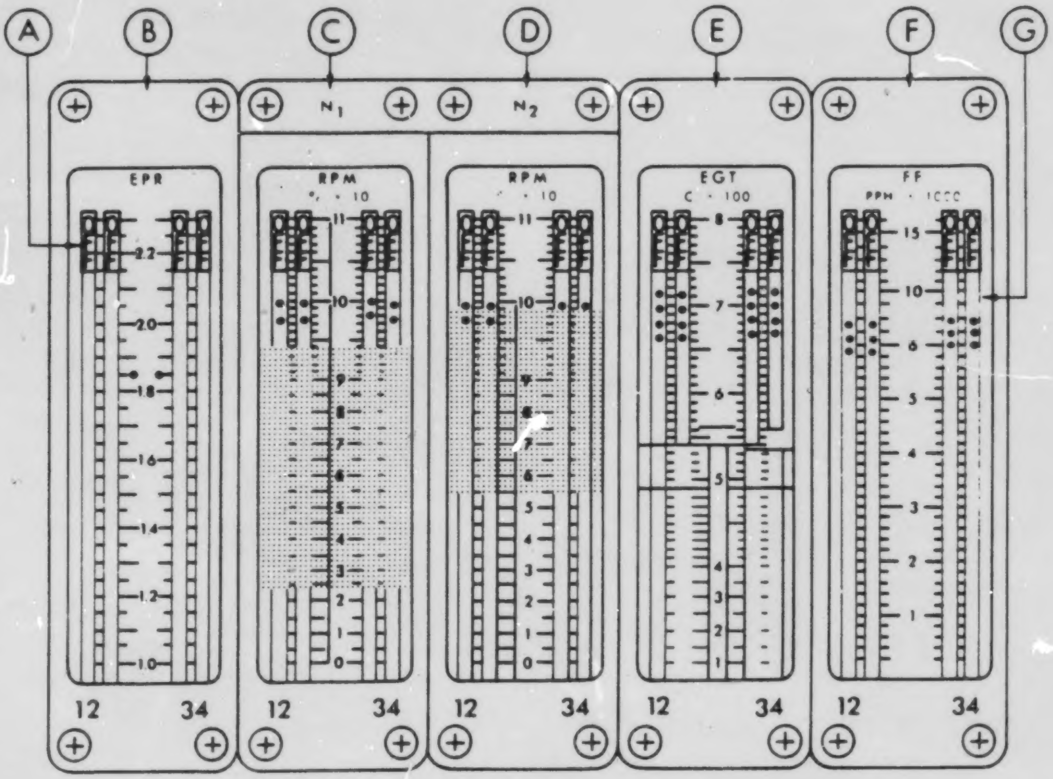

E
F
F
E
D
TOTAL
M
V
G
C
T
F
E
J
K
L
SELECT
A
N
Y
M
M
b
U
S
H
C
P
P2

Figure 84. Select and Total Indicator.

VERTICAL SCALE ENGINE INSTRUMENT SYSTEMS


A
B
C
D
E
F
G
N1
N2
EPR
RPM
% × 10
RPM
% × 10
EGT
C × 100
FF
PPH × 1000
12
34
12
34
12
34
12
34
12
34

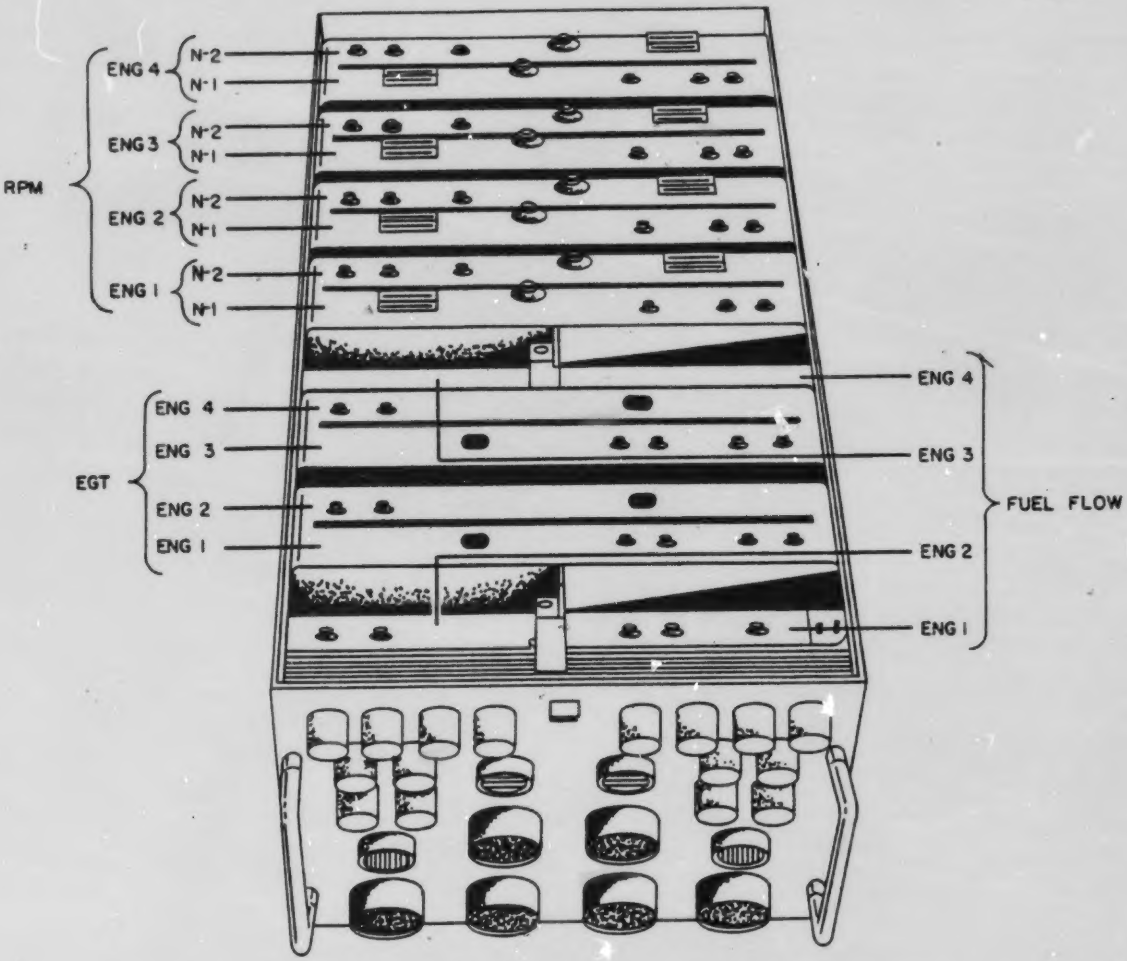
A POWER OFF INDICATORS
B ENGINE PRESSURE RATIO INDICATOR
C TACHOMETER (RPM) INDICATOR (N_1)
D TACHOMETER (RPM) INDICATOR (N_2)
E EXHAUST GAS TEMPERATURE INDICATOR
F FUEL FLOW INDICATOR
G MOVABLE TAPES

Figure 85. Vertical Scale Indicators.

NOTES

606

585



RPM
ENG 4
N-2
N-1
ENG 3
N-2
N-1
ENG 2
N-2
N-1
ENG 1
N-2
N-1
EGT
ENG 4
ENG 3
ENG 2
ENG 1
FUEL FLOW
ENG 4
ENG 3
ENG 2
ENG 1

Figure 86. Vertical Scale Indicating System Converter.

NOTES

607

NOTES

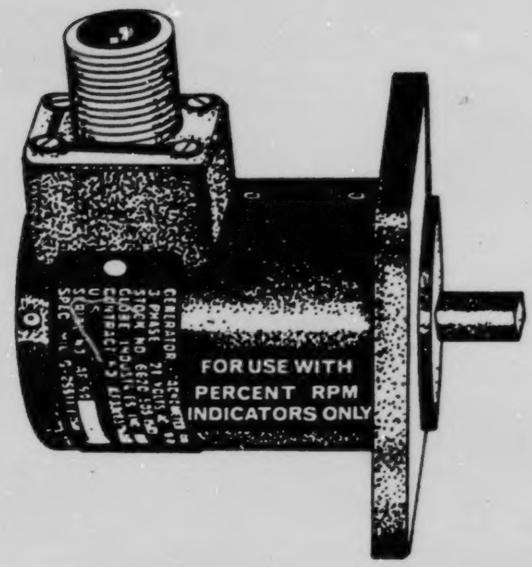

FOR USE WITH
PERCENT RPM
INDICATORS ONLY
GENERATOR
3 PHASE
STOCK NO
CONTRACT

Figure 87. Tachometer Generator.

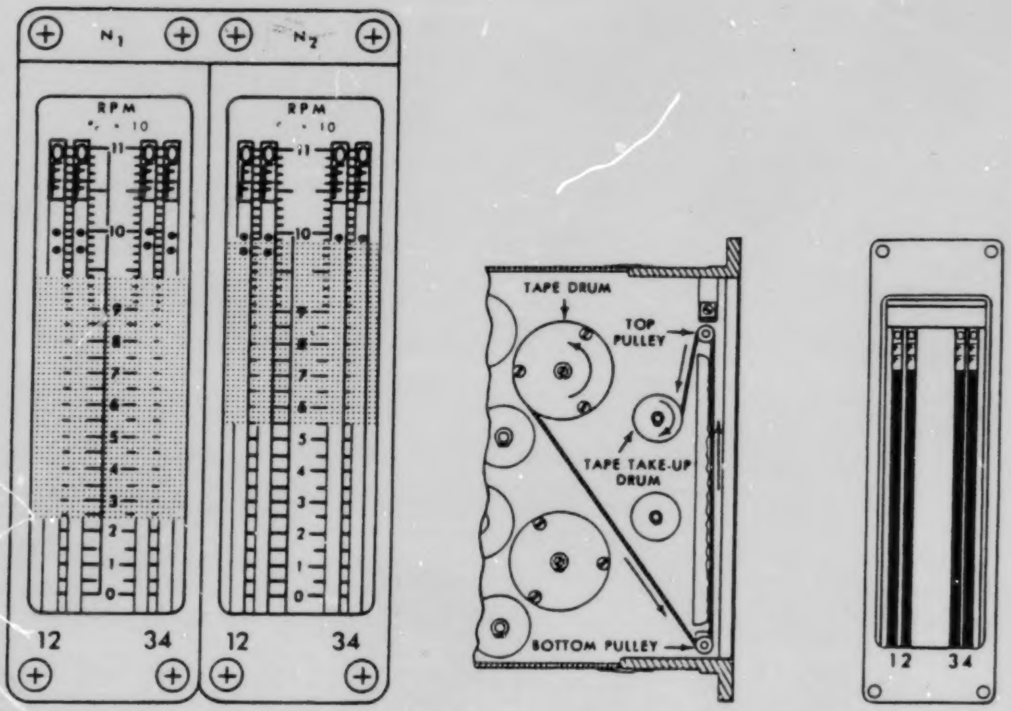

N1
N2
RPM
% × 10
11
10
9
8
7
6
5
4
3
2
1
0
12
34
TAPE DRUM
TOP PULLEY
TAPE TAKE-UP DRUM
BOTTOM PULLEY
12
34

Figure 88. Vertical Scale Tachometer Indicator.

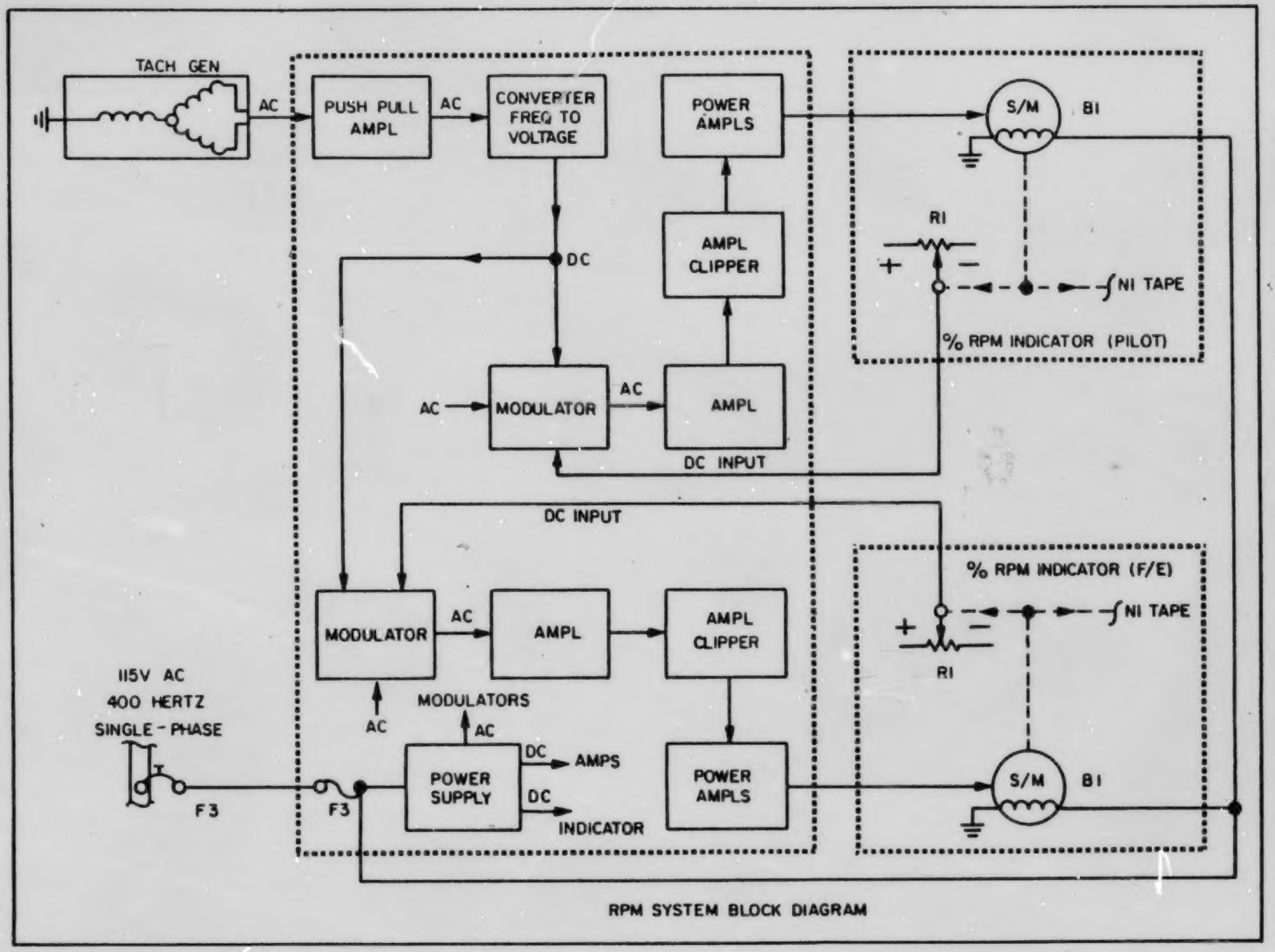
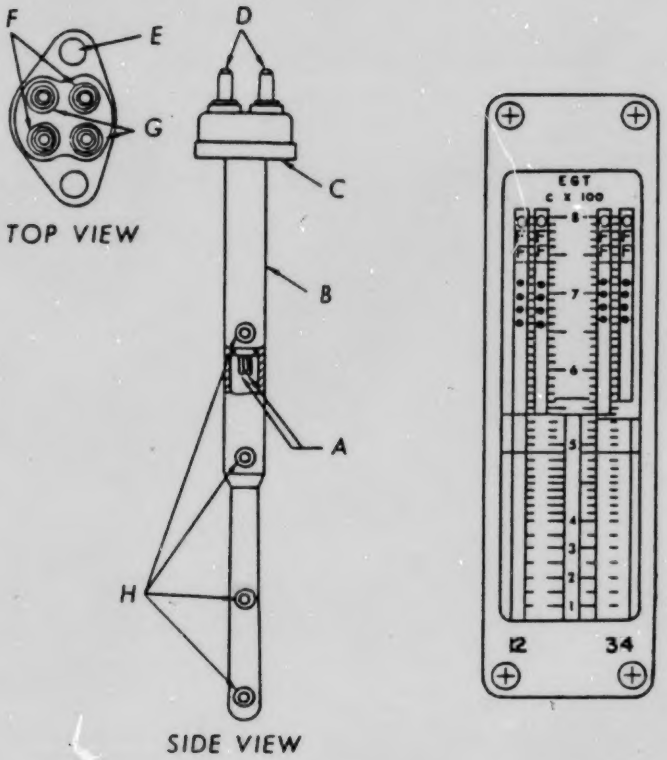

TACH GEN
AC
PUSH PULL AMPL
AC
CONVERTER FREQ TO VOLTAGE
POWER AMPLS
S/M
B1
AMPL CLIPPER
R1
+
−
NI TAPE
% RPM INDICATOR (PILOT)
DC
AC
MODULATOR
AC
AMPL
DC INPUT
DC INPUT
% RPM INDICATOR (F/E)
+
−
NI TAPE
MODULATOR
AC
AMPL
AMPL CLIPPER
R1
115V AC
400 HERTZ
SINGLE - PHASE
AC
MODULATORS
AC
DC
AMPS
POWER SUPPLY
DC
INDICATOR
POWER AMPLS
S/M
B1
F3
F3
RPM SYSTEM BLOCK DIAGRAM

Figure 89. Vertical Scale Tachometer System Block Diagram.


F
E
D
G
C
TOP VIEW
B
A
H
SIDE VIEW
EGT
C X 100
8
7
6
5
4
3
2
1
12
34

A. THERMOCOUPLES
B. PROBE
C. MOUNTING FLANGE
D. TERMINAL POST
E. MOUNTING HOLES
F. ALUMEL CONNECTING POST
G. CHROMEL CONNECTING POST
H. EXHAUST GAS INLET-OUTLET PORTS

Figure 90. Vertical Scale Thermocouple and Indicator.

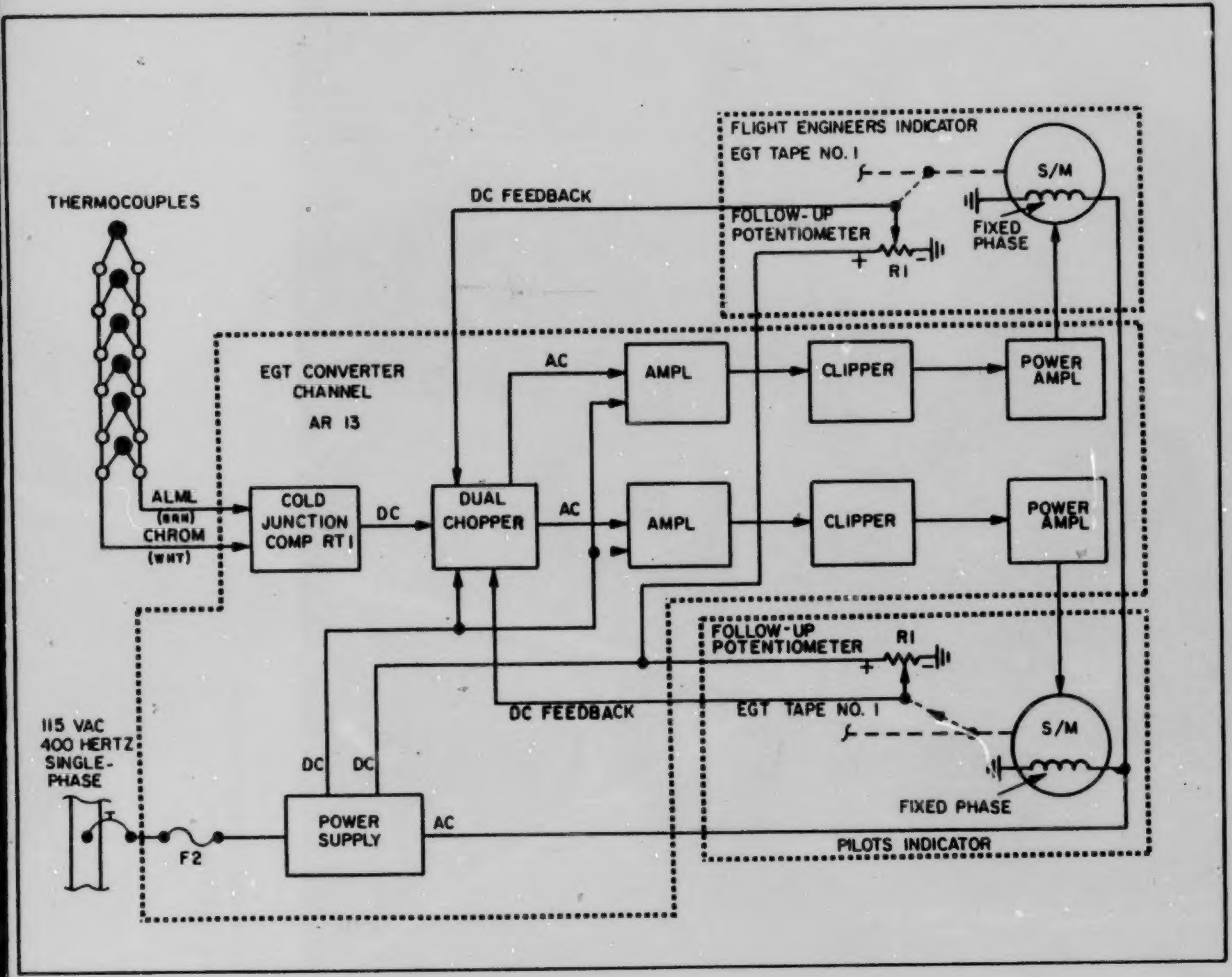

FLIGHT ENGINEERS INDICATOR
EGT TAPE NO. 1
S/M
THERMOCOUPLES
DC FEEDBACK
FOLLOW-UP POTENTIOMETER
+
R1
FIXED PHASE
EGT CONVERTER CHANNEL
AR 13
AC
AMPL
CLIPPER
POWER AMPL
ALML
(BRN)
CHROM
(WHT)
COLD JUNCTION COMP RT1
DC
DUAL CHOPPER
AC
AMPL
CLIPPER
POWER AMPL
FOLLOW-UP POTENTIOMETER
R1
+
DC FEEDBACK
EGT TAPE NO. 1
S/M
115 VAC
400 HERTZ
SINGLE-PHASE
DC
DC
FIXED PHASE
POWER SUPPLY
AC
F2
PILOTS INDICATOR

Figure 91. Vertical Scale Thermocouple System Block Diagram.

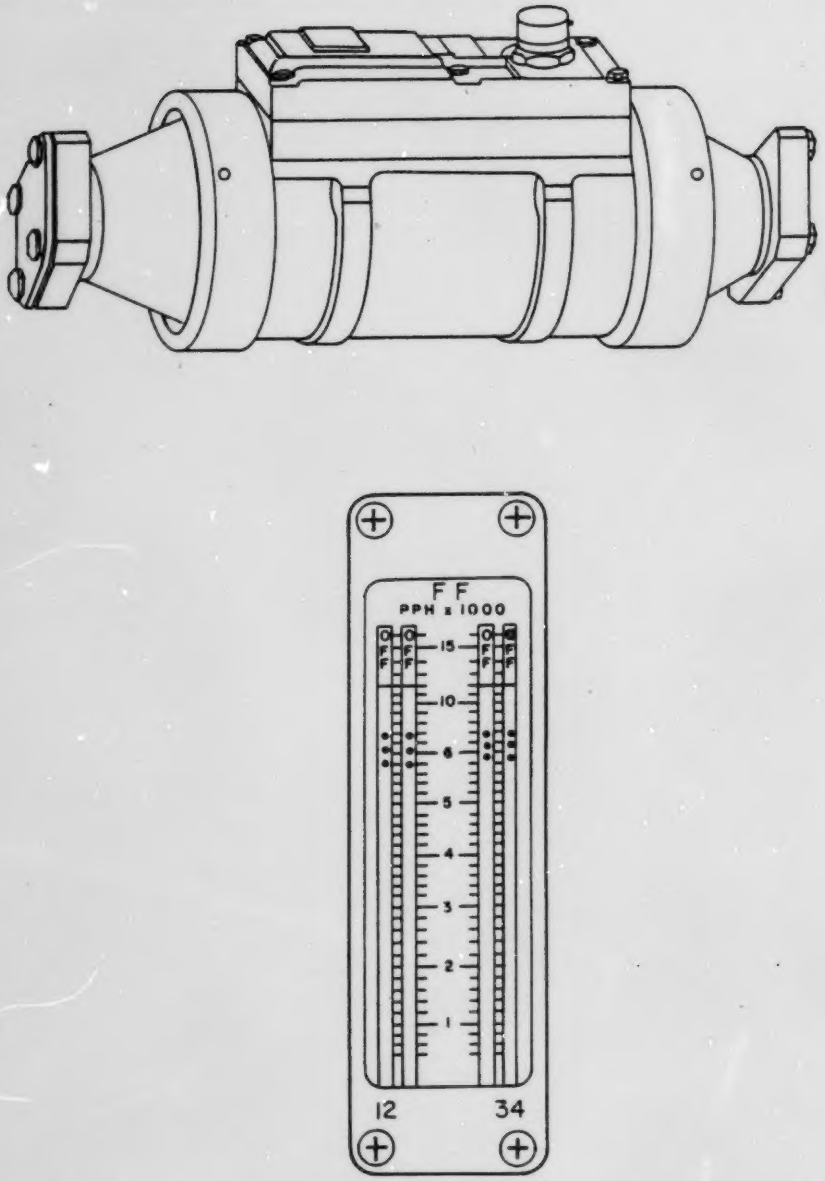

F F
PPH x 1000
O
F
F
15
10
6
5
4
3
2
1
12
34

Figure 92. Vertical Scale Fuel Flow Transmitter and Indicator.

592

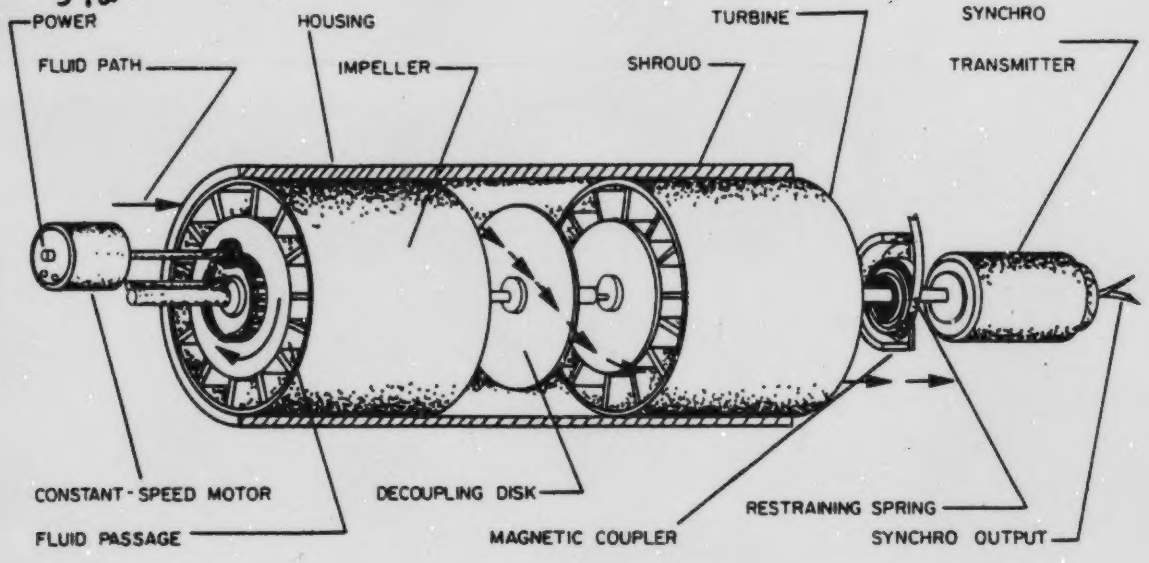

POWER
HOUSING
TURBINE
SYNCHRO
TRANSMITTER
FLUID PATH
IMPELLER
SHROUD
CONSTANT-SPEED MOTOR
FLUID PASSAGE
DECOUPLING DISK
MAGNETIC COUPLER
RESTRAINING SPRING
SYNCHRO OUTPUT

Figure 93. Cutaway of Vertical Scale Fuel Flow Transmitter.

NOTES

613

593

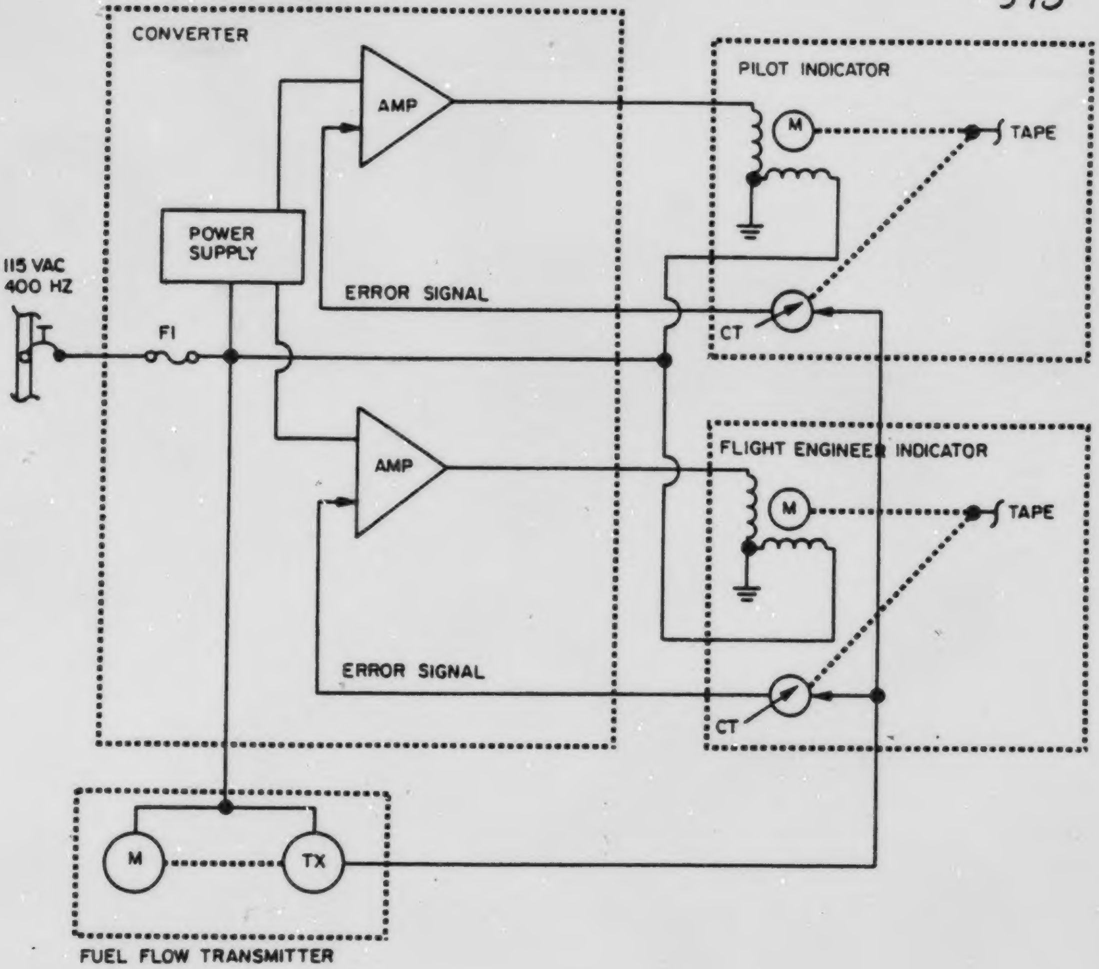

CONVERTER
AMP
PILOT INDICATOR
M
TAPE
POWER SUPPLY
115 VAC
400 HZ
F1
ERROR SIGNAL
CT
AMP
FLIGHT ENGINEER INDICATOR
M
TAPE
ERROR SIGNAL
CT
M
TX
FUEL FLOW TRANSMITTER

Figure 94. Vertical Scale Fuel Flow System Block Diagram.

NOTES

614

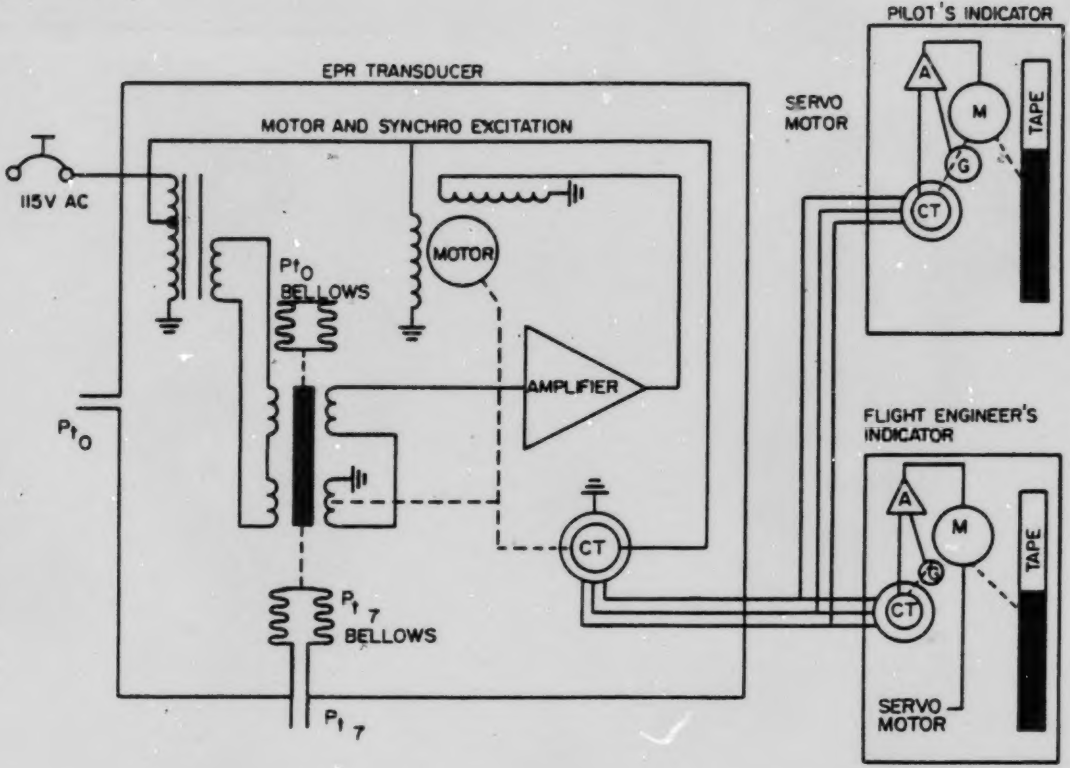

EPR TRANSDUCER
MOTOR AND SYNCHRO EXCITATION
115V AC
P_{t_0} BELLOWS
MOTOR
AMPLIFIER
P_{t_0}
CT
P_{t_7} BELLOWS
P_{t_7}
SERVO MOTOR
PILOT'S INDICATOR
A
M
G
CT
TAPE
FLIGHT ENGINEER'S INDICATOR
A
M
G
CT
TAPE
SERVO MOTOR

Figure 95. Vertical Scale Engine Pressure Ratio System Block Diagram.

NOTES

HANDOUT
3ABR32531-HO-200-2

Technical Training

Avionics Instrument Systems Specialist

ENGINE INSTRUMENTS
(HOMEWORK)

19 November 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

Flight Training Devices & Instrument Branch
Chanute AFB, Illinois

3ABR32531-HO-200-2

INSTRUCTIONS

This handout contains questions to be answered after each day of class. Each page is marked as to which day it is to be completed. Your instructor will check your work the next morning. DO NOT WORK AHEAD!

POSITION INDICATING SYSTEMS

Day 1

1. List the components of the wheel position indicating system. ____

2. What is the purpose of the hairspring in the wheel position indicator?

3. What is the principle of operation of the wheel position indicator?

4. What is the purpose of the flap position indicating system?

5. What is the relationship electrically of the two wipers in the flap position transmitter? ____

6. What is the pointer attached to in the flap position indicator?

7. In the flap position indicator, what causes the pointer to indicate "off-scale up" when power is lost to the system? ____

8. The electrical taps (pick-off points) are arranged how many degrees apart in the flap position transmitter? ____

9. What is another name for a self-synchronous indicating system?

Supersedes ST 3ABR32531-HO-200-2, 5 July 1979.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 600; TTVSA - 1

10. What component of the landing gear indicator is used to display gear-up, crosshatch, and gear-down indications? ________________

11. What are the power requirements for the (A) landing gear position indicating system and the (B) flap position indicating system?

(A) ____________ (B) ____________

12. An operational check of any system should be preceded by a complete ________________ of the system components and accessible wiring.

13. For safety reasons, what personal items should be removed prior to working on electronic systems? ________________

PRESSURE INDICATING SYSTEMS

Day 2

1. What type pressures are measured by direct reading pressure indicators?

____

2. What is used as the reference pressure in a pressure measuring system with a dual sensing element? ________________

3. The Bourdon tube is designed so that as pressure is applied to the tube it ________________.

4. In a synchro indicating system, where is power applied to and how much? ________________

5. What is the temperature compensating device in a single element direct pressure indicator? ________________

6. Why is the synchro in the pressure transmitter sometimes referred to as a synchro generator? ________________

7. How are the stators of the synchros in the pressure indicating systems wound? ________________

8. What is the principle of operation of the pressure transmitter synchro? ________________

9. What is the principle of operation of the synchro indicator?

____

10. What is the pressure sensing element of the variable reluctance indicating system? ________________

11. What type of circuit is the variable reluctance indicating system?

____

12. In the bench check of an indicator, the difference between "before tap" and "after tap" readings is known as ____________ ____________.

13. What is the purpose of the thermistors in the variable reluctance indicator? ________________________

14. What is the purpose of slippage marks? ________________

15. What does a red radial range mark indicate? ______________

TACHOMETER INDICATING SYSTEMS

Day 3

1. How do tachometer systems indicate engine speed in reciprocating and jet aircraft? ________________________

2. What is the output of a tachometer generator? ______________

3. How is the 3-phase output of a 2-pole tachometer system transmitted through a 2-wire harness? ____________________

4. What determines the frequency of the tachometer generator output?

____

5. What are the two basic sections of a tachometer indicator?

____

6. What is used to prevent pointer oscillation in the tachometer indicator? ________________________

7. What keeps the pointer from spinning in the tachometer indicator?

____

8. What effect does an increase in engine RPM have on the generator voltage and frequency outputs? __________________

9. The tachometer indicating system is a ____________ sensitive system.

10. The effective magnetic poles of a 4-pole generator rotor are arranged at what distance apart? __________________

11. What are the three parts of the synchronous motor assembly in a tachometer indicator? ______________________

12. The minimum speed switch is placed in the N-1 overspeed system for what purpose? ____________________________________

TEMPERATURE INDICATING SYSTEMS

Day 4

1. What type of resistance thermometer temperature bulb is used to measure free air temperature? ____________________________

2. Why is nickel wire used in resistance temperature bulb construction?
____

3. What is the purpose of the springs in the resistance type temperature indicator? ____

4. The indicator in the resistance type temperature indicating system utilizes what type meter movement? ______________________

5. Gasket type thermocouples are used to measure __________ __________ temperature on _______________________ aircraft.

6. What is the purpose of the variable resistor in the thermocouple type temperature indicating system? ___________________________

7. How are the thermocouple probes connected if more than one is used?
____

8. How is the variable resistor connected in the thermocouple type temperature indicating system? ___________________________

9. Which thermocouple lead on a jet aircraft is the negative lead?
____

10. What is a thermocouple? ____________________________________

11. What is the power requirement for the thermocouple type temperature indicating system? ____________________________________

FUEL FLOW INDICATING SYSTEMS

Day 5

1. What component in the fuel flow transmitter moves the vane to a "no flow" position? ______________________________________

2. How much vane movement is available for the first 3000 pph of fuel flow? ____

3. What device is installed in the transmitter to compensate for a stuck vane? ________________________________

4. What keeps fuel from getting into the electrical portion of the fuel flow transmitter? ________________________

5. Why is it necessary to increase the excitation voltage to the linear synchro rotor in the fuel flow transmitter when flows exceed 3000 pph?

____

6. How are the different linear synchros from the separate engines connected electrically? Why? ____________________

7. What is the signal nulling unit in the fuel flow totalizer indicator?

____

8. What is used as a dampening device to prevent pointer overdrive and oscillations in the fuel flow totalizer indicator? __________

9. What activates the hi-lo switch in the fuel flow transmitter?

____

10. How is the motion of the vane in the metering chamber of the transmitter transmitted to the electrical section? ______________

11. What single component of the fuel flow indicating system is common to both the individual and the totalizer systems? __________

ENGINE PRESSURE RATIO SYSTEM

Day 6

1. List the components of the EPR system. ______________

____

2. The ____________ converts the difference between Pt2 and Pt7 pressures into an electrical signal.

3. When the engine is operating, Pt7 is __________ than Pt2.

4. The indicator uses two synchro motors to drive the pointer. What are they called? ________________________

5. The AiResearch transducer uses a _________, ________ ________, and a __________ ____________ to convert pressures (Pt2 and Pt7) into mechanical movement.

6. What determines which of the two transistors is forward biased thus causing the DC motor to run? ________________

7. Explain the basic operation of the Minneapolis-Honeywell transducer.

____

____

8. What is the voltage requirement of the EPR system? ______________

9. In the AiResearch transducer, power for the indicator and transducer synchros is tapped off of the ______________ of transducer transformer T1.

10. Transformer T1 in the transducer steps down the AC and the ________ are used to supply power for the operation of the motor and the transistors.

RESISTANCE TYPE LIQUID QUANTITY SYSTEM

Day 7

1. The resistance type quantity indicating system is sometimes referred to as the ____________ ____________ liquid quantity indicating system.

2. What device is used to prevent liquid from entering the electrical section of the transmitter? ______________________________

3. What are the parts used to make up the mechanical linkage which connects the bellows lever to the wiper arm of the transmitter and explain the primary function of this mechanical linkage. ________

____

4. What controls the amount of current flow to the indicator coils?

____

5. The indicator uses primarily a ____________ type meter movement.

6. The indicator dial is calibrated to read in ____________ of fuel.

7. The two stationary coils in the indicator called "deflection coils" are used to deflect the __________ __________ ______________ when current passes through them.

8. What is used to pull the pointer "off scale" when power is lost?

____

9. What is used to determine the range of pointer movement and what are the three common ranges? ______________________________________

10. What adjustments are made to calibrate the ohmic value of the resistance strip in the transmitter? ______________________________________

CAPACITANCE LIQUID QUANTITY INDICATING SYSTEM

Day 8

1. What are the power requirements of the capacitance type fuel quantity indicating system? ______________________________

2. List the five major components of the capacitance fuel quantity system.

____

____

3. What is the purpose of the fuel gage select switch? ______________________________

____

4. What is the purpose of the compensator probe and how is it connected in the system? ______________________________

5. The ________ lead carries the power from the ____________ ______ to the ________ __________ and then the ____________ lead carries the capacitance signal back to the ______________ ______________ to be amplified.

6. How are the tank units in the capacitance fuel quantity system connected? ______________________________

7. The ________ __________ ______ provides empty capacitance signal when the drop tanks are not installed.

8. What is the normal indication when the fuel gage test switch is depressed and held? ______________________________

9. What are the power requirements for the liquid oxygen indicating system (LOX)? ______________________________

10. The LOX indicator reads from 0 to _____ ____________ of oxygen.

VERTICAL SCALE INDICATING SYSTEMS

Day 9

1. What four systems are typically found in the vertical scale systems?

____

2. List the components found in the vertical scale tachometer indicating system. ______________________________

3. What determines the output voltage and frequency of the tachometer generator? ______________________________

4. Briefly describe the converter unit used in the vertical scale indicating system. ____

5. Briefly define the purpose of the converter channel board for the tackometer system. ____________________________________

6. One set of vertical scale indicators is mounted on the pilot's panel and the other set is on the __________ ______________ panel.

7. What indications do the N1 and N2 tachometer systems represent?

____

8. If power is applied to the tachometer vertical scale indicating system, but the engine is not running, what process takes place resulting in the blank indication on the indicator? ________________________

____

____

9. In the vertical scale EGT system, what is used to help prevent erosion of the thermocouple probes? _____________________________

10. What is provided as the input signal to the vertical scale converter EGT channel boards? __________________________________

11. The cold junction compensator provides a constant millivolt reference to the dual chopper regardless of ______________ changes.

12. The fuel flow transmitter provides an output signal directly to the control transformer in the ______________________.

13. List the seven components that make up the fuel flow transmitter.

____

____

14. The vertical scale fuel flow indicating system is sometimes referred to as a __________________ system.

15. The principle operation of the EPR transducer in the vertical scale EPR indicating system is based on the use of a ___________ ________ _____.

16. What is the purpose of the rate generator in the vertical scale EPR indicating system? ______________________________________

604

PROGRAMMED TEXT
3ABR32531-PT-~~201~~202
3ABR32632B-PT-303

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionics Systems Specialist

PRESSURE INDICATING SYSTEMS

29 July 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

605

Instrument Flight Control Branch
Chanute AFB, Illinois

3ABR32531-PT-203
3ABR32632B-PT-303

FOREWORD

This programmed text was developed for use in Courses 3ABR32531, Avionics Instrument Systems Specialist and 3ABR32632B, Integrated Avionics Systems Specialist. The material contained here has been validated with 38 students from the subject courses. Thirty-five students achieved the objectives as stated. Average time to complete the text is 120 minutes.

OBJECTIVES

Without reference, identify facts pertaining to the purpose, operation, and/or characteristics of typical pressure indicating systems with an accuracy of at least 80%.

a. Direct

b. Synchro

c. Variable Reluctance

Without references, identify facts pertaining to the application of instrument range markings, with an accuracy of at least 80%.

INSTRUCTIONS

This programmed text is divided into three sections: Section A covers Direct Pressure and Range Markings, Section B covers Synchro Pressure, and Section C covers Variable Reluctance Pressure. The information presented in this text is presented in small steps called "frames". After reading the information in the frames you are asked to actively respond to the statements at the end of that frame. Place these responses on the response sheet provided with this text. Check your responses for accuracy with the correct responses given after the following frame. If you make an incorrect response, reread the frame until you determine why you were in error before proceeding to the next frame. After completing each section you will take an appraisal to display your attainment of the stated objectives before proceeding to the next area of instruction. Work as quickly as possible, but DO NOT RUSH!

Supersedes 3ABR32531-PT-201, 3ABR32632B-PT-303, 10 February 1976; 3ABR32531-PT-207, 3ABR32632B-PT-304, 6 February 1975; 3ABR32531-PT-208, 3ABR32632B-PT-303A, 31 January 1975.
OPR: 3360TTG
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3360TTGTC-W - 250; TTVSR - 1

626

Section A. DIRECT PRESSURE

Frame 1

Although direct pressure indicating systems are not as common on today's aircraft as they were on the older type aircraft, the operating principles are still used in modern instrument systems. Since direct pressure indicating systems were often used to measure the pressure of flammable oil, fuel, etc., the hazard of a bursting fuel line in the cockpit area was always present. To decrease or eliminate this hazard sophisticated electronic instruments were developed. Keep in mind, that even though new systems were developed there are still aircraft in the field that use direct pressure indicating systems and you will probably be performing maintenance on them. The direct pressure indicating system, as the name implies, is used to show the pilot or crew members the amount of pressure that is available in a particular aircraft system. Some of the direct pressure systems and their uses are listed in the chart below.

Direct Pressure System	Used for
1. Oil Pressure	Lubricating oil to moving engine parts.
2. Fuel Pressure	Fuel pressure to engine's carburetor.
3. Vacuum Pressure	Air driven gyroscopic flight instruments.
4. Manifold Pressure	Intake pressure to the engine manifold.
5. Hydraulic Pressure	Landing gear, flaps, brakes, etc.

Circle the letter of the correct statement(s).

1. A direct pressure indicating system indicates the

   a. gallons of fuel in the fuel tanks.
   b. acceleration of the aircraft.
   c. pressure available in an aircraft system.
   d. pressure altitude of the aircraft.

2. A direct pressure system that indicates the pressure in the brake system is the

   a. manifold pressure system.
   b. vacuum pressure system.
   c. deicer pressure system.
   d. hydraulic pressure system.

Frame 2

Direct reading pressure gages operate whenever the system that they are used in operates. There are two categories of direct pressure gages. One category is the absolute pressure type and the other category is the differential pressure type. Absolute pressure is the total pressure above zero. It is called a total pressure because atmospheric pressure is always present on all objects on the earth. Differential pressure is then said to be the difference between two pressures which is usually the difference between a systems pressure and atmospheric pressure. Most direct pressure gages that are used are the differential pressure type. Figure 1 below shows a typical direct pressure indicating system.

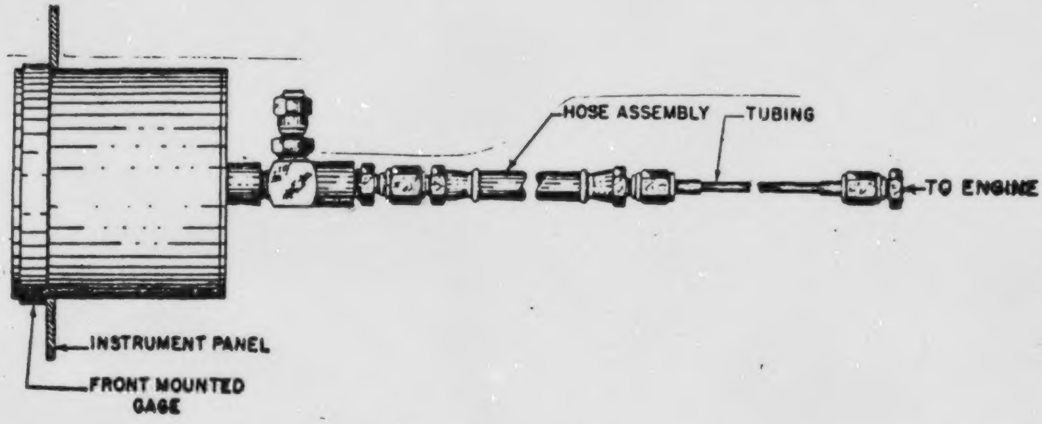


Figure 1.

Circle the letter of the correct statement(s).

a. All direct pressure gages measure absolute pressure or differential pressure.

b. Direct pressure gages operate only when they are turned "ON".

c. Most direct pressure gages measure differential pressure.

Answers to Frame 1: 1. c 2. d

To measure the pressure of the various aircraft pressure systems, a device that responds to pressure must be used. This device is a pressure-sensitive element. There are four different pressure-sensitive elements that could be used, but only one, the Bourdon tube, will be covered here. The other pressure-sensitive elements will be covered in other blocks of instruction.

The Bourdon tube responds to pressure changes by straightening out (expanding) when pressure increases, and coiling closer (contracting) when pressure decreases. Direct pressure gages and the remote indicating systems operate on this principle of pressure-sensitive elements responding to pressure and to pressure changes.

Circle the letter of the correct statement(s).

a. Direct pressure gages do not use a pressure-sensitive element.

b. The Bourdon tube is one of the four sensing elements.

c. An increase in pressure will cause the Bourdon tube to coil closer.

Answers to Frame 2: a, c

Frame 4

Bourdon tubes are used to measure high pressures such as oil, fuel, hydraulic, or air pressure. A Bourdon tube is a coiled hollow elliptical metal tube which is anchored at the open end ("P"). The other end of the tube is closed, connected to a link, and is free to move. Because of the Bourdon tube's construction, it acts like a spring and tends to straighten out when internal pressure is applied. See figure 2 below.

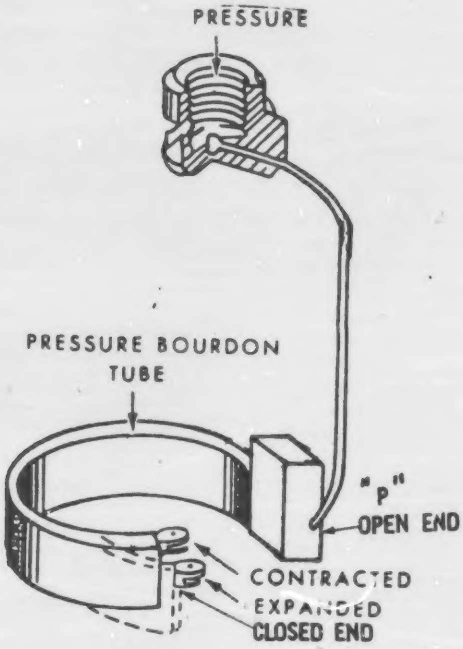

PRESSURE
PRESSURE BOURDON TUBE
"P"
OPEN END
CONTRACTED
EXPANDED
CLOSED END

Figure 2.

Circle the letter of the correct statement(s).

- a. A Bourdon tube is a coiled, round, metal tube.
- b. The closed end of the Bourdon tube is free to move.
- c. Bourdon tubes are used to measure high pressure.

Answers to Frame 3: b

Frame 5

Now let's see how a small movement of the pressure-sensitive element is changed into a large amount of pointer travel or movement. As pressure enters the Bourdon tube the closed end of the tube begins to expand (straighten out). Attached to this closed end of the tube is a connecting link. This link is attached to a sector gear. When the tube straightens or coils the link is moved and causes the sector gear to pivot and drive a pinion gear. The pinion gear, when driven, rotates the pointer. The amount of pointer movement is dependent upon the size of the sector and pinion gears. The large sector gear driving a small pinion gear magnifies (increases) the movement of the pointer in relation to the movement of the Bourdon tube. See figure 3 below.

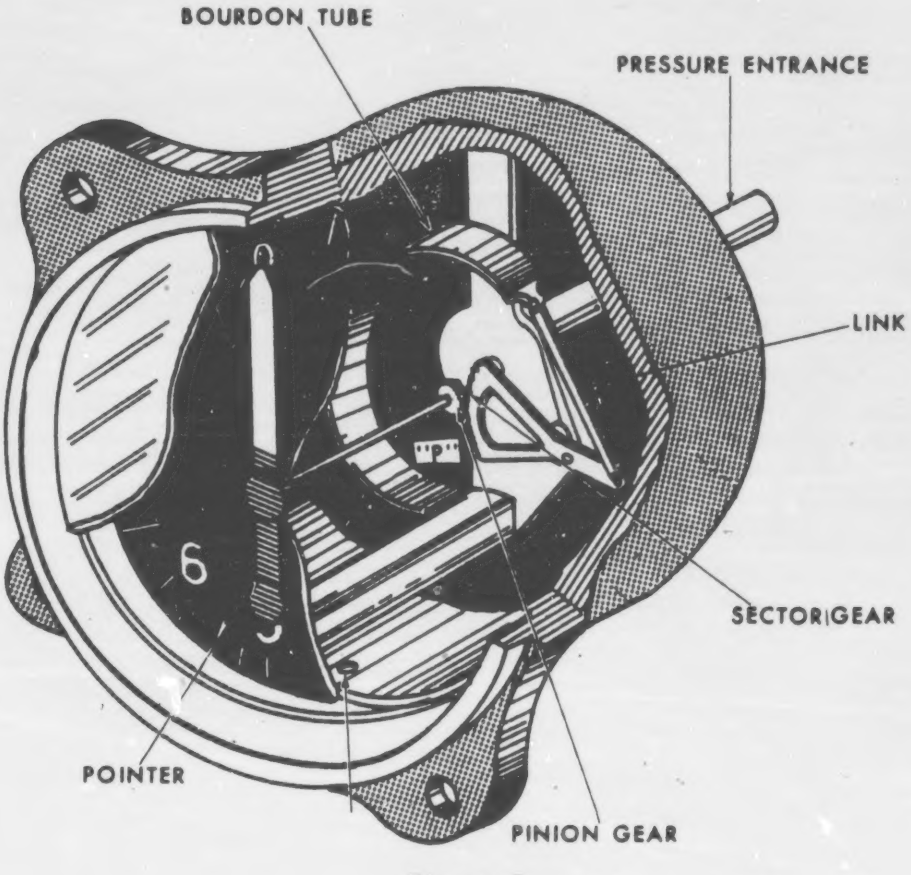


Figure 3.

Circle the letter of the correct statement(s).

a. Pressure entering the Bourdon tube will cause the closed end to coil.

b. A small movement of the Bourdon tube is magnified in pointer travel by the size of the sector and pinion gears.

c. The closed end of the Bourdon tube is connected to a link.

Answers to Frame 4: b, c

Frame 6

The absolute pressure type gage indicates the total pressure which is the sum of the system pressure and the atmospheric pressure. Since the atmospheric pressure is different at different altitudes the indication would change even though the system pressure remained the same. To correct for this erroneous indication the differential pressure type gage is used. By placing the Bourdon tube in a vented case, as the aircraft climbs in altitude the atmospheric pressure surrounding the Bourdon tube decreases. Theoretically, this decrease in pressure on the outside of the Bourdon tube would cause it to straighten. However, remember that the atmospheric pressure on the substance to be measured also decreases with altitude. Therefore, the reduced pressure on the outside of the Bourdon tube is compensated for by the decrease in pressure on the surface of the substance to be measured. Consequently, the pressure gage indicates the correct pressure at all altitudes. Vented case instruments are used ONLY in aircraft that fly at low altitudes (2,000 to 5,000 feet).

Circle the letter of the correct statement(s).

a. Atmospheric pressure decreases as altitude increases.

b. A decrease in atmospheric pressure on the Bourdon tube is compensated for by an increase in pressure on the substance to be measured.

c. In a vented case, a change in atmospheric pressure on the Bourdon tube is equal to the atmospheric pressure on the substance to be measured.

d. Only differential pressure type gages compensate for atmospheric pressure changes.

Answers to Frame 5: b, c

You may recall from previous lessons in block I that indicators with vented (raintight) cases were never to be used in aircraft with pressurized cabins. Pressurization inside the cabin is normally higher than atmospheric pressure and that will cause the indication to read low. In these aircraft a dual sensitive element contained in an airtight case must be used. See figure 4 below. With the pressure to be measured, connected to "P", and atmospheric pressure from outside the cabin (cockpit) connected to "V", the system would operate as follows: When the atmospheric pressure on the (fuel, oil etc.) decreases, the pressure Bourdon tube would coil and try to move Link A to the left, but since the atmospheric pressure on the substance decreased, it also decreased in the vented Bourdon tube. This allows the vented Bourdon tube to coil and move Link B to the right. With Links A and B trying to move in opposite directions with equal force the sector shaft will not move and thus the indication remains the same.

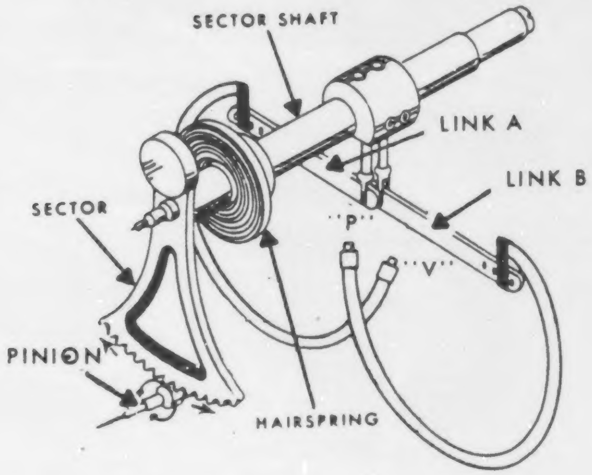


Figure 4.

Circle the letter of the correct statement(s).

a. In pressurized cabins, dual sensitive elements are contained in a vented case.

b. Atmospheric pressure changes are compensated for by a dual sensitive element.

c. A dual sensitive element is required with an airtight case.

d. Atmospheric pressure changes are compensated for by one Bourdon tube opposing the movement of the other.

e. Movement of the Bourdon tube is aided by the movement of the other Bourdon tube.

Answers to Frame 6: a, c, d

Frame 8

Most metals expand with an increase in temperature and contract with a decrease in temperature. Therefore, as the temperature of the pressure gage changes, the indication would change due to the expanding or contracting of the Bourdon tubes. In pressure gages with dual sensitive elements this would not be a problem because a temperature increase will cause both tubes to expand. The two tubes are equal and there is no movement at the free ends because the opposing forces, due to temperature changes, neutralize each other.

Circle the letter of the correct statement(s).

a. An increase in temperature causes most metals to contract.

b. With dual sensitive elements, a change in temperature is neutralized by one tube opposing the other.

Answers to Frame 7: b, c, d

Since different metals expand and contract in varying amounts and rates with temperature changes, a bimetallic (two different metals laminated together) segment tail (figure 5A) can be used to compensate pressure gages with single sensitive elements for temperature changes. Suppose we use the metals iron and aluminum in a bimetallic segment. Aluminum expands and contracts much more than iron. As the temperature increases, the aluminum expands. However, the iron laminated to the aluminum does not expand as much as the aluminum. The only way the expansion of the aluminum can take place is by curving or bending around the iron (figure 5B). As the temperature increases, the pressure sensitive element straightens, but at the same time the bimetallic segment becomes shorter because of the bending action. Therefore, the straightening of the element is compensated for by the bending ot the bimetallic segment.

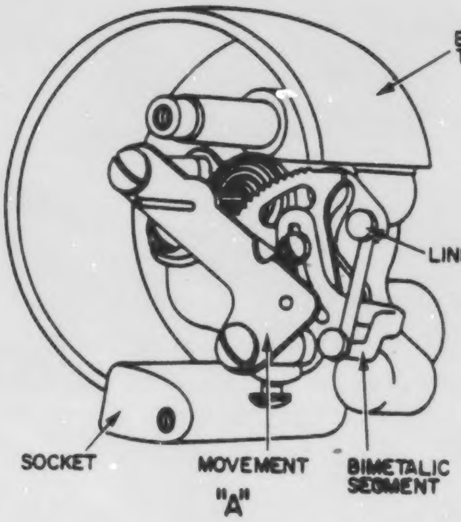


Figure 5A.

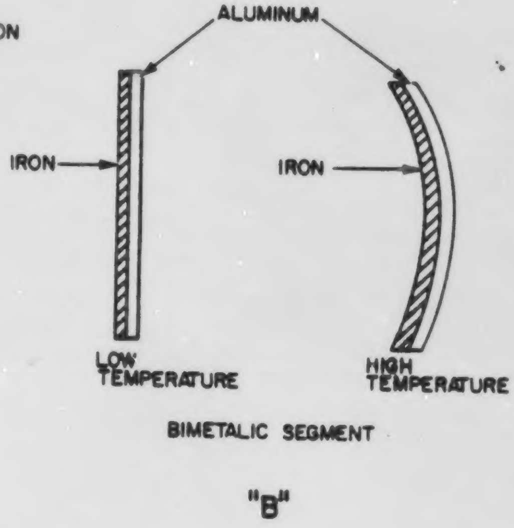


Figure 5B.

Circle the letter of the correct statement(s).

a. A bimetallic segment tail is used to compensate for temperature changes in pressure gages with a single sensitive element.

b. In the bimetallic segment tail, iron contracts and expands more than aluminum.

c. Due to a temperature change, an expansion of the pressure sensitive element is compensated for by the bending of the bimetallic segment.

Answer to Frame 8: b

615

Frame 10

When you install an indicator that requires range or limit markings, you must apply the appropriate range markings. The range and limit markings show the pilot at a glance whether flight operation is safe, desirable, or unsafe. Instructions for installing range markings are listed in TO 5-1-2. The ranges and lmiits of the indicators are in the aircraft -1 flight manual.

Circle the letter of the correct statement(s).

a. All instruments will have range markings.

b. The application of range markings is covered in TO 5-1-2.

c. 1B-52H-1, and 1F-111A-1 are flight manuals.

d. Instrument specialists will install range markings.

Answers to Frame 9: a, c

636

All range markings except the white radial (slippage index mark) are decals and are applied to the cover glass covering a range of the indicator scale. The white radial is painted on the indicator cover glass and extends onto the case in a straight unbroken line. This mark is applied on the indicator in an area that has no other range markings or indicator scale. See figure 6 below. The white radial must be applied when range markings are used. This enables the pilot to determine if the cover glass has slipped and the range markings are inaccurate in relation to their position over the dial numbers.

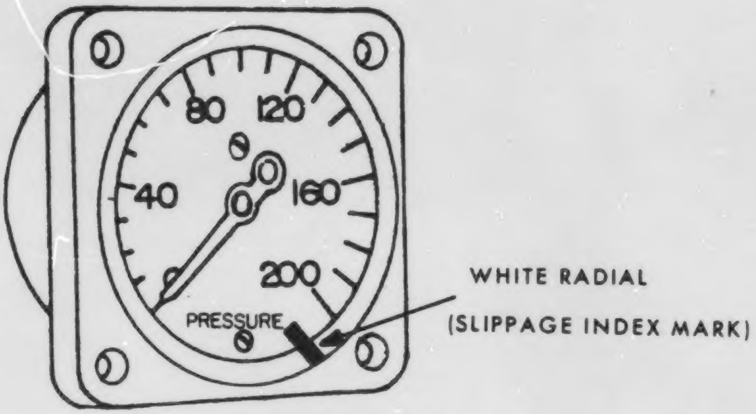


Figure 6.

Circle the letter of the correct statement(s).

a. The white radial should extend from the case onto the cover glass in a straight unbroken line.

b. The white radial indicates an area of limited operation.

c. A shift of cover glass is apparent when the white radial is not a continuous straight line.

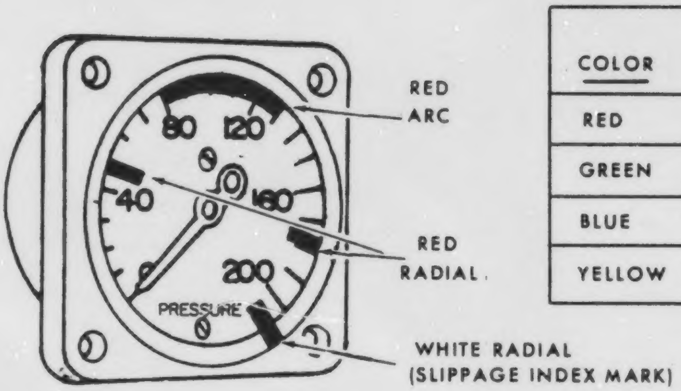
d. With the exception of the white radial, all range markings are decals.

e. Range markings are applied directly to the case.

Answers to Frame 10: 1. b, c, d

Frame 12

There are two types of decal range markings; the Radial and the Arc. The range markings are shown in figure 7 below. The red radial is used to indicate minimum or maximum operation. The arc type range marking can be of four different colors, each meaning a different type of operation. See the chart below for the color, operation, meaning and type of aircraft it can be used on.



COLOR	OPERATION	AIRCRAFT USED ON
RED	PROHIBITED	ALL TYPES
GREEN	NORMAL	ALL TYPES
BLUE	AUTO-LEAN	PROPELLER
YELLOW	UNDESIREABLE	ALL TYPES

Figure 7.

Circle the letter of the correct statement(s).

a. Red and green arc range markings are used on propeller type aircraft only.

b. The green arc is the range marking for normal operation.

c. A red radial indicates the maximum or minimum operation limit for all aircraft.

Answers to Frame 11: a, c, d

Answers to Frame 12: b, c

Return to the beginning of this programmed text and review the objectives. When you are satisfied that you know and understand the material you will be required to demonstrate this understanding by successfully completing an appraisal on the stated objectives. After successful completion of the appraisal you will proceed to the laboratory to perform on an actual direct pressure system.

APPRAISAL

Section B. SYNCHRO PRESSURE

Frame 1

Machines that have moving parts require some type of lubrication. Lubrication is necessary to reduce friction and heat created by the m-ving parts rubbing together. If friction and hear are not reduced, excessive wear of moving parts will cause premature failure of the machine. Lubrication plays a very important role in the life and durability of all types of engines. For example, the lubricating system in an automobile engine takes oil from the oil pan (sump), filters it and forces it under pressure to the bearings and all moving parts. The oil drains back into the oil pan and the cycle is repeated again and again. Thus, cleaned and cooled oil is continually supplied to the moving parts to reduce friction and heat. It is important that a means of monitoring the pressure be available. Any extreme variation in pressure can cause damage to the engine. Therefore, we must have a dependable and accurate pressure indicating system.

It is also important to have a means of monitoring hydraulic oil pressure. Since most all modern aircraft utilize hydraulic pressure to move control surfaces, raise and lower landing gear, and perform a variety of other motion-related functions, the malfunction of a hydraulic pressure system can lead to the loss of an aircraft and possibly the death or injury of crew members.

This programmed text uses an engine oil pressure indicating system as a representation of a synchro pressure system. By changing the scale value on the indicator to 0-400, 1000 psi and replacing the Bourdon tube (sensing device) to one constructed of a heavier material, the same basic system covered in this programmed text can be used for hydraulic pressure indications.

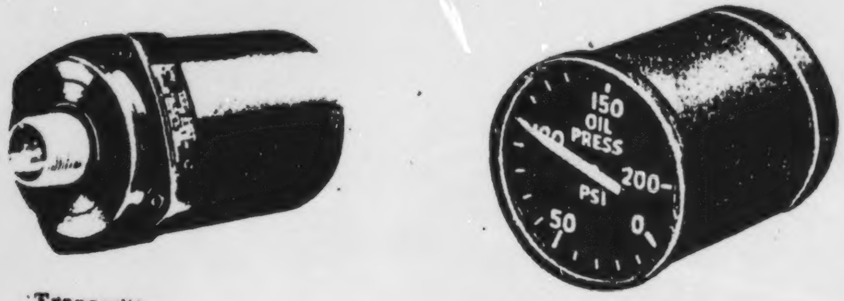
NO RESPONSE REQUIRED

6·19

Frame 2

Since aircraft engines are lubricated by oil under high pressure, they require an accurate oil pressure indicating system.

Some aircraft engine oil pressure indicating systems are synchronous systems. They consist of a pressure transmitter on each engine and an indicator on the pilot's instrument panel for each engine. See figure 8. The indicator is calibrated in pounds per square inch. The transmitter is electrically connected to the indicator.



Transmitter

Indicator

Figure 8.

Refer to figure 8 to answer the following questions. Circle the letter for the correct response to the following statement(s).

1. The dial of the oil pressure indicator is graduated from

   a. 0 to 200 pounds per square foot.
   b. 0 to 200 ounces per square foot.
   c. 0 to 200 pounds per square inch.
   d. 0 to 200 ounces per square inch.

2. A four engine aircraft would have

   a. one indicator and four transmitters.
   b. one transmitter and four indicators.
   c. two indicators and four transmitters.
   d. four indicators and four transmitters.

Section B. SYNCHRO PRESSURE

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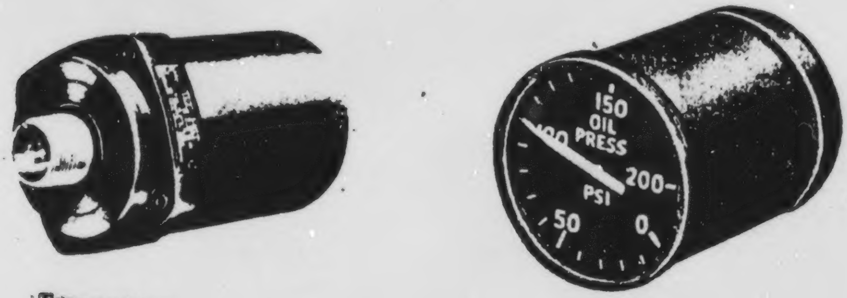

Transmitter

Indicator

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   a. 0 to 200 pounds per square foot.
   b. 0 to 200 ounces per square foot.
   c. 0 to 200 pounds per square inch.
   d. 0 to 200 ounces per square inch.

2. A four engine aircraft would have

   a. one indicator and four transmitters.
   b. one transmitter and four indicators.
   c. two indicators and four transmitters.
   d. four indicators and four transmitters.

The oil pressure transmitter and indicator are connected to each other by electrical wiring. See figure 9. The 26VAC, 400-Hertz single-phase power is taken from the aircraft electrical system and is connected to the rotors of the transmitter and indicator.

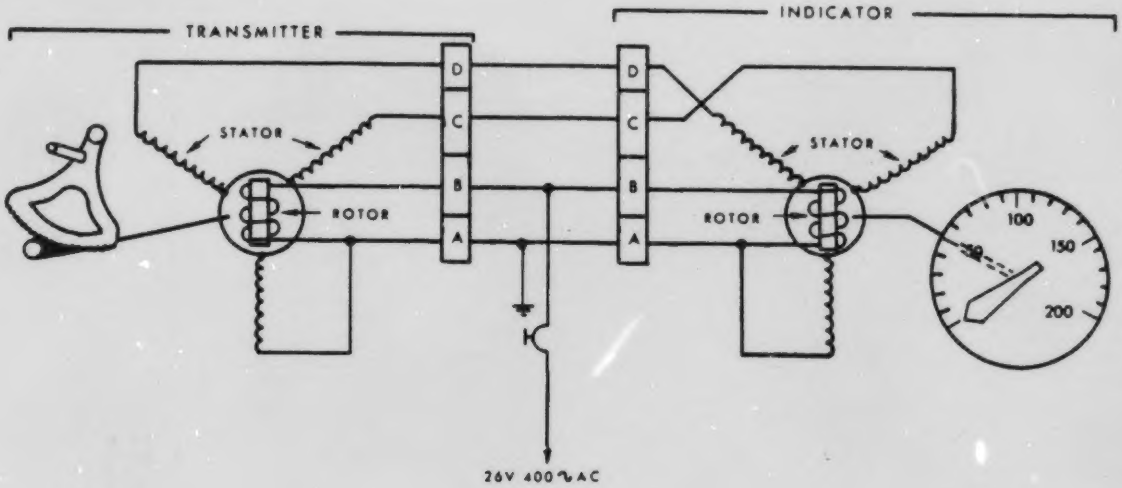

TRANSMITTER
INDICATOR
STATOR
STATOR
ROTOR
ROTOR
D
C
B
A
D
C
B
A
100
150
50
200
26V 400∿AC

Figure 9.

Refer to figure 9 to answer the following question. Circle the letter of the correct response to the following statement.

1. The 26VAC 400-Hertz power is connected to

   a. one rotor and one stator.
   b. both rotors and both stators.
   c. both rotors.
   d. both stators.

Answers to Frame 2: 1. c 2. d

Frame 4

The oil pressure transmitter is a hermetically sealed unit that converts oil pressure into an electrical signal. It is mounted on or near the engine, and engine oil pressure is applied to an opening in one end of the case. See figure 10 for an illustration of the transmitter with the case removed. Two Bourdon tubes, two links, an arbor (rotating shaft) and two gears make up the mechanical assembly that measures oil pressure. Notice the hairspring that is attached to the generator rotor shaft. This spring takes up gear backlash (play due to clearance between gear teeth).

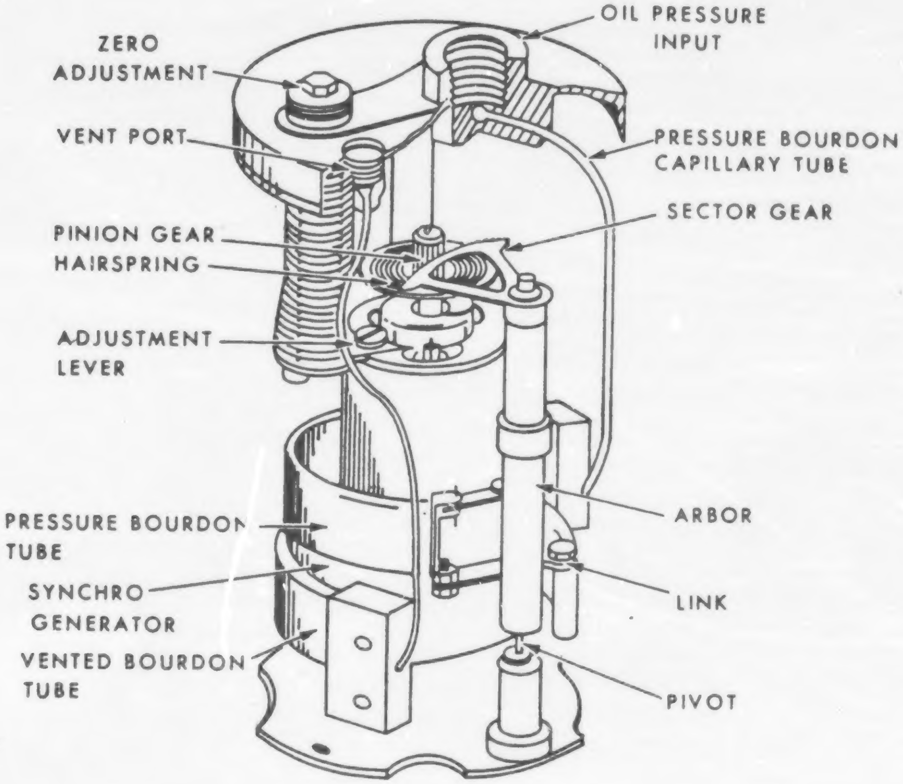

ZERO ADJUSTMENT
OIL PRESSURE INPUT
VENT PORT
PRESSURE BOURDON CAPILLARY TUBE
SECTOR GEAR
PINION GEAR
HAIRSPRING
ADJUSTMENT LEVER
ARBOR
PRESSURE BOURDON TUBE
SYNCHRO GENERATOR
LINK
VENTED BOURDON TUBE
PIVOT

Figure 10.

Refer to figure 10 to answer the following question. Circle the letter of the correct response to the following statement.

1. The hairspring is used to

   a. help turn the gears.
   b. help turn the rotor.
   c. prevent backlash of the gears.
   d. keep the generator rotor from spinning.

Answers to Frame 3: 1. c

Frame 5

The two Bourdon tubes in the transmitter are the pressure Bourdon tube and the vent Bourdon tube. First we will take up the pressure Bourdon tube. The pressure Bourdon tube is a flat, "C" shaped metal tube that is closed on one end. When pressure is applied to the inside of the tube, it expands to a greater diameter. See figure 11A. When the pressure is released, the surrounding pressure forces it back to its original diameter. The amount of movement at the closed end of the tube depends on the difference of pressures inside the tube as opposed by the pressure (differential) outside the tube.

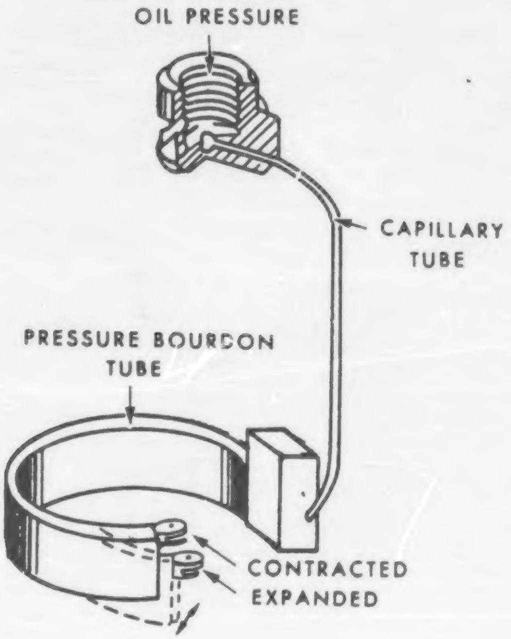


Figure 11A.

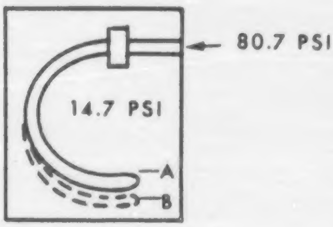


Figure 11B.

Refer to figure 11B to answer the following questions. Circle the letter for the correct response to the following statements.

1. As oil pressure on the Bourdon tube increases, the tube will

   a. remain in position "A".
   b. move from position "A" to "B"
   c. remain in position "B".
   d. move from position "B" to "A".

2. The differential pressure that moves the Bourdon tube is

   a. 14.7 psi.
   b. 66.0 psi.
   c. 80.7 psi.
   d. 95.4 psi.

Answer to Frame 4: 1. c

Frame 6

The vented Bourdon tube is a flat "C" shaped metal tube that is closed on one end. This tube is vented to atmospheric pressure. The reason for this is that it compensates for atmospheric pressure changes. As the airplane goes higher, the pressure inside the tube decreases causing the tube to contract. As the airplane descends, the pressure becomes higher and the tube expands. See figure 12.

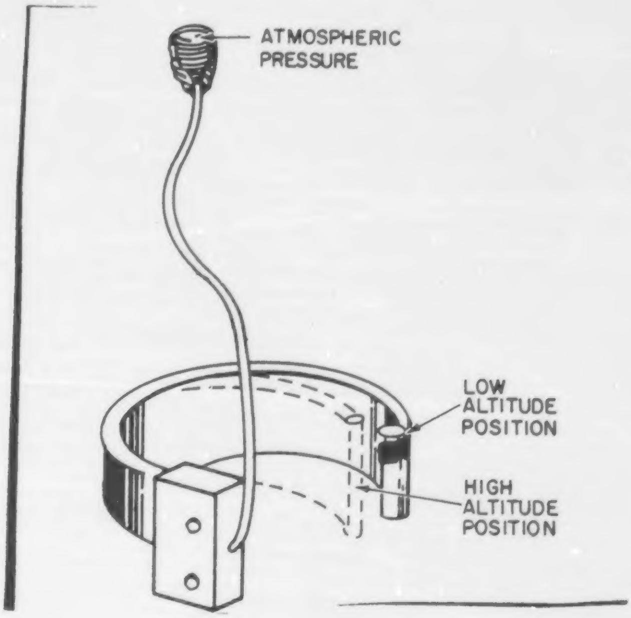


Figure 12.

Refer to figure 12 to answer the following question. Circle the letter of the correct response to the following statement.

1. The vented Bourdon tube

   a. expands as the aircraft climbs.
   b. compensates for varying oil pressure.
   c. compensates for varying atmospheric pressure.
   d. compensates for varying atmospheric temperature.

Answers to Frame 5: 1. b 2. b

The closed end of the oil pressure Bourdon tube and the vented Bourdon tube are mechanically linked. As the airplane gains altitude, the atmospheric pressure decreases causing the vented Bourdon tube to contract. As this tube contracts, it applies a force to the oil pressure Bourdon tube forcing it to expand. The movement of both tubes maintains a desired differential pressure so regardless of the altitude, the oil pressure indicator reading will REMAIN constant. The vented Bourdon tube makes this possible.

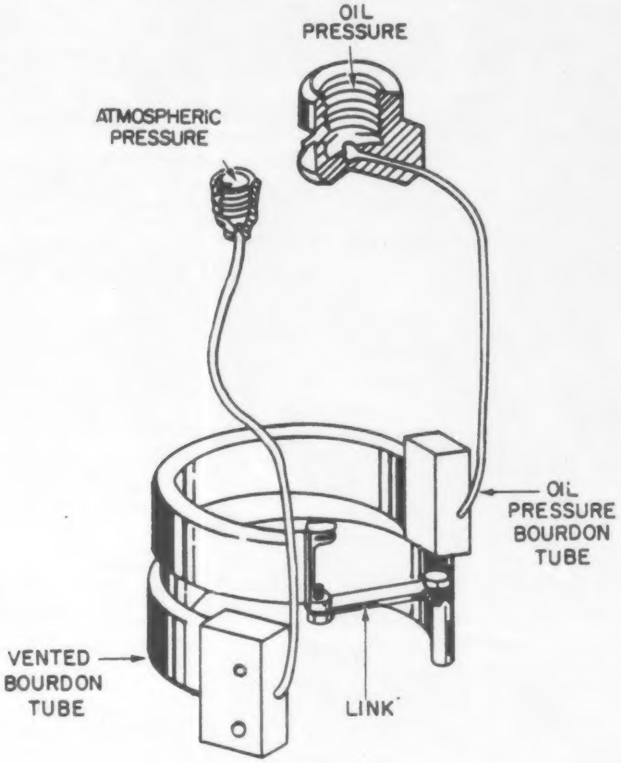


Figure 13.

Refer to figure 13 to answer the following question(s). Circle the letter of the correct response to the following statement(s).

1. Pressure inside the vented Bourdon tube is

   a. oil pressure.
   b. gage pressure.
   c. differential pressure.
   d. atmospheric pressure.

2. The purpose of the vented Bourdon tube is to

   a. correct for mechanical wear.
   b. correct for oil pressure surges.
   c. correct for varying atmospheric pressure.
   d. compensate for thermal expansion of the oil.

Answer to Frame 6: 1. c

Frame 8

The closed end of the oil pressure Bourdon tube is connected to the arbor shaft assembly, sector gear, and pinion gear. Notice the pinion gear is mounted on the generator rotor shaft and is mechanically meshed with the sector gear. See figure 14. When oil pressure increases, the pressure tube expands causing the arbor shaft to rotate. This will rotate the sector gear, pinion gear and the synchro generator shaft. The synchro generator shaft does NOT spin BUT it displaces the rotor just a few degrees. This displacement of the rotor produces an electrical signal in the indicator.

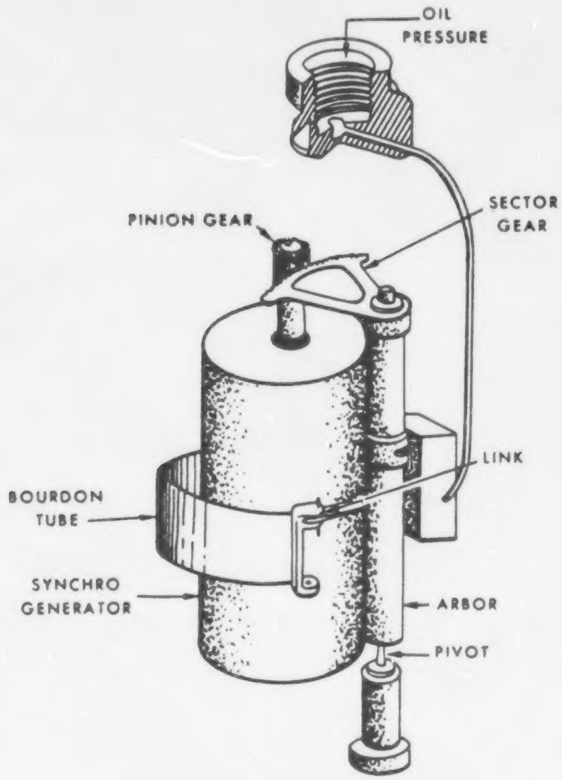


Figure 14.

Refer to figure 14 to answer the following questions. Circle the letter of the correct response to the following statements.

1. The sector and pinion gears are turned by the
   a. rotor of the generator.
   b. arbor shaft assembly.
   c. vented Bourdon tube.
   d. synchro generator.

2. The pinion gear of the autosyn transmitter is
   a. mounted on the sector gear.
   b. mounted on the rotor shaft.
   c. turned by the generator stator.
   d. turned by the sector gear.

Answers to Frame 7: 1. d 2. c

The synchro generator looks like any other small electric motor or generator. It consists of a "wye" wound stator assembly and a rotor. The rotor is a soft iron core with a coil of wire wound around it. The 26VAC, 400-Hertz single-phase power enters the rotor through a set of brushes and slip rings. See figure 15 for an illustration of the rotor and stator windings.

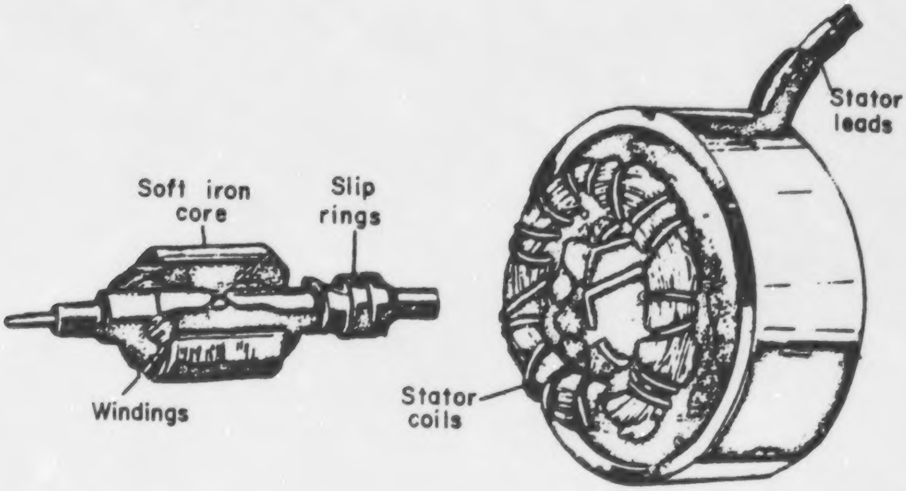


Figure 15.

Refer to figure 15 to answer the following question(s). Circle the letter(s) for the correct response to the following statement(s).

1. The 26VAC, 400-Hertz single-phase power

   a. is connected to the stator.
   b. is connected to the rotor.
   c. turns the rotor.
   d. turns the stator.

2. The stator is

   a. delta wound.
   b. series wound.
   c. "wye" wound.

Answers to Frame 8: 1. b 2. b, d.

Frame 10

Most electromechanical systems include an adjustment device. Wear of mechanical parts and metal fatigue (weakening of metal due to bending or flexing) of the Bourdon tubes causes slight errors that must be reduced. By adjusting the transmitter zero adjuster screw, the synchro stator assembly is rotated slightly and an accurate voltage signal is then sent to the indicator. This adjustment is accomplished with electrical power on and no oil pressure applied to the transmitter--that is why it is called the zero adjustment. As the zero adjustment is turned, the synchro stator turns, while the position of the rotor remains fixed. See figure 16. The zero adjustment screw extends outside the transmitter case.

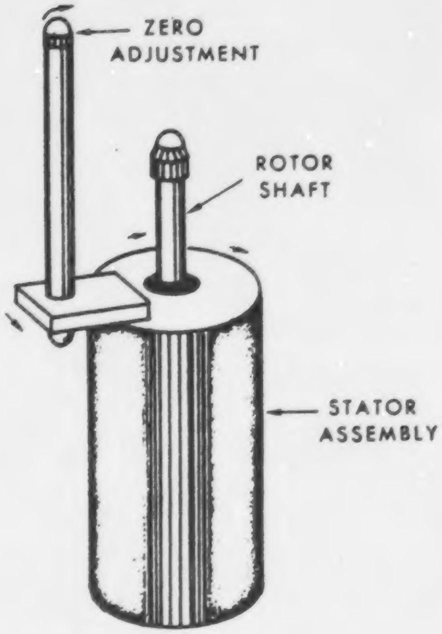


Figure 16.

Circle the letter(s) of the correct response(s) to the following statement(s).

1. An example of metal fatigue is a

   a. worn gear.
   b. Bourdon tube with a worn shaft.
   c. Bourdon tube with a hole through its wall.
   d. a spring that has been stretched too far.

2. The adjustment screw turns the

   a. synchro rotor.
   b. synchro stator.
   c. arbor assembly.
   d. transmitter.

Answers to Frame 9: 1. b 2. c

To understand the principles of operation of a synchro transmitter, it is first necessary to understand certain transformer principles. A transformer consists of a primary and a secondary coil wound on a soft iron core. It is used to either increase or decrease voltage, as illustrated in figure 17. Alternating current flowing through the primary always induces alternating current in the secondary. The ratio of turns of the two coils determines whether it is a step-up or step-down transformer.

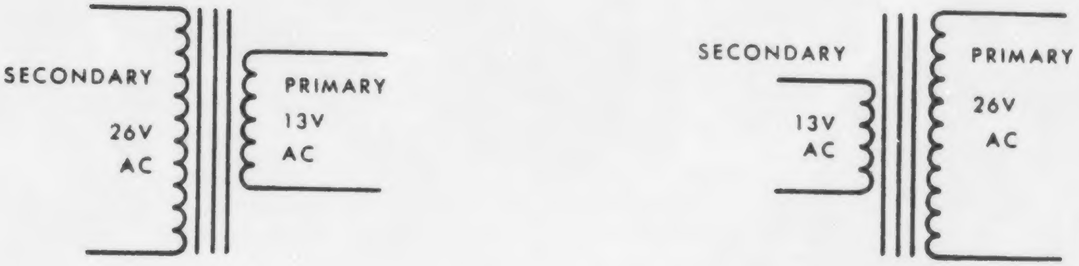


Figure 17.

Refer to figure 17 and circle the letter(s) of the correct response(s) for the following statement(s).

1. Current in a transformer secondary circuit is

   a. direct current.
   b. alternating current.
   c. pulsating direct current.
   d. higher than current in the primary.

2. The voltage increase or decrease of a transformer is determined by the

   a. soft iron core.
   b. ratio of turns in the coils.
   c. insulation between the coils.
   d. output of the secondary coils as compared to primary coils.

Answers to Frame 10: 1. d 2. b

Frame 12

A variable transformer may also be used to increase or decrease AC voltage. Voltage that is induced into the secondary may be varied by changing thy position of one coil in relation to another. Refer to figure 18. Notice that when both coils are parallel, maximum voltage is induced into the secondary. Secondary voltage gradually decreases as the primary (rotor) moves away from parallel. Minimum induction occurs when the rotor coil is at ninety degrees in relation to the secondary coil.

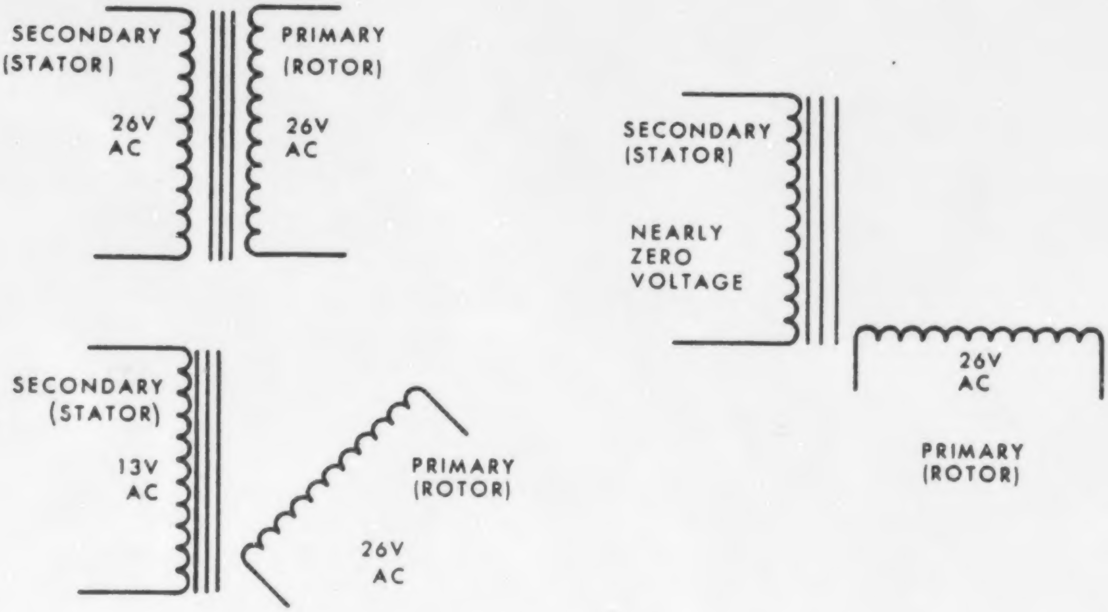

SECONDARY (STATOR)
26V AC
PRIMARY (ROTOR)
26V AC
SECONDARY (STATOR)
NEARLY ZERO VOLTAGE
26V AC
PRIMARY (ROTOR)
SECONDARY (STATOR)
13V AC
PRIMARY (ROTOR)
26V AC

Figure 18.

NO RESPONSE REQUIRED

Answers to Frame 11: 1. b, d 2. b

The synchronous generator used in the oil pressure transmitter is a variable transformer. The primary (rotor) is a single coil of fine wire wound on a soft iron core and energized by 26VAC, 400-Hertz single-phase. The three coils are "wye" wound to form the stator assembly. See figure 19. As the Bourdon tube expands or contracts, rotor position changes and induced voltage varies in each of the three stator (secondary) coils. The relative position of the rotor and stator coils in figure 19 indicates that maximum voltage is being induced into coil 1 since it is parallel to the rotor. Coil 2 has the same induced voltage as coil 3, but the induced voltage in each of these coils is less than coil 1.

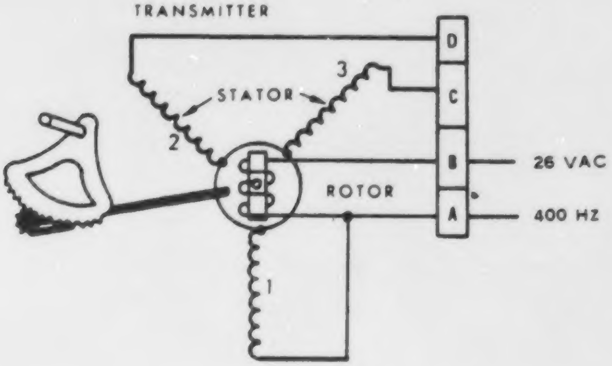


Figure 19.

Refer to figure 19 to answer the following question(s). Circle the letter of the correct response to the following statements.

1. The transmitter stator is

   a. moved by the Bourdon tube.
   b. energized directly by 26VAC.
   c. the primary and is stationary.
   d. the secondary and is stationary.

2. Maximum voltage is induced into coil 3 when

   a. the rotor is parallel to coil 1.
   b. the rotor is parallel to coil 3.
   c. the three stator coils are parallel to each other.
   d. coil 1 and the rotor are at 90° in relation to each other.

633

Frame 14

The oil pressure indicator contains a synchronous motor consisting of a "wye" wound stator and a rotor assembly. Current is fed to the indicator through an electrical connector and the rotor is energized through brushes and/or slip rings. Thy only moving part is the rotor which is attached directly to the pointer. There are no gears, hairsprings or mechanical stops. The rotor is free to turn through 360°. When electrical power is interrupted, the pointer will remain at its last position. The indicator is hermetically sealed and has no external adjustment.

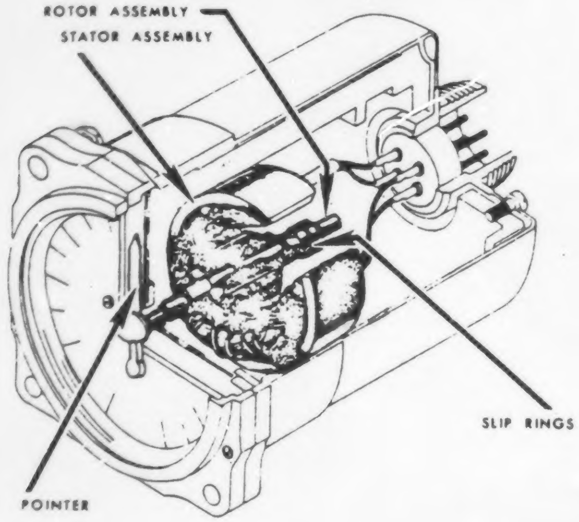


Figure 20.

Refer to figure 20 to answer the following questions. Circle the letter of the correct response for the following statements.

1. The indicator rotor turns the pointer by

   a. being attached directly to it.
   b. a set of gears.
   c. a set of gears and a hairspring.
   d. a set of hairsprings and a calibrating spring.

2. The rotor of the indicator is energized through

   a. permanent connections.
   b. slip rings and/or brushes.
   c. hairsprings.
   d. hairsprings and a calibrating spring.

Answers to Frame 13: 1. d 2. b

654

The indicator rotor is a coil of fine wire wound on a soft iron core and energized by 26VAC, 400-Hz single-phase power. The indicator synchronous motor is not a variable transformer, the stator coils are energized by voltage from the transmitter stator. Current in the indicator stator coils produces an electromagnetic field which will attract the electromagnetic field of the rotor. The rotor will align itself parallel to the stator coil having the highest current flow (the strongest magnetic field). The indicator operates on the principle of attraction of electromagnetic fields. See figure 21.

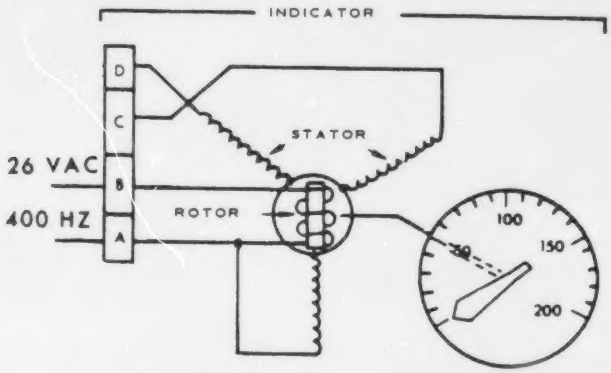


Figure 21.

Refer to figure 21 to answer the following questions. Circle the letter(s) of the correct response to the following statements.

1. The indicator rotor

   a. is energized by 26VAC.
   b. has three windings.
   c. is moved by electromagnetic attraction.
   d. is the primary and is stationary.

2. The indicator stator

   a. is an electromagnet.
   b. is geared to the pointer.
   c. movement is restricted by a hairspring.
   d. is energized by voltage from the transmitter stators.

Answers to Frame 14: 1. a 2. b

635

Answers to Frame 15:   1. a, c   2. d

Return to the beginning of the programmed text and review the objectives. When you are satisfied that you know and understand the material you will take an appraisal. After passing the appraisal you will proceed to the lab to perform on an actual synchro pressure system.

APPRAISAL

656

Section C. VARIABLE RELUCTANCE

Frame 1

The variable reluctance pressure system is used on several Air Force aircraft. This system is used to measure engine oil pressure in pounds per square inch. The variable reluctance pressure system operating principle differs from that of the synchro pressure system. In the following frames we will discuss the system components and operating principles. See figures 22 and 23 for cutaway views of the indicator and transmitter.

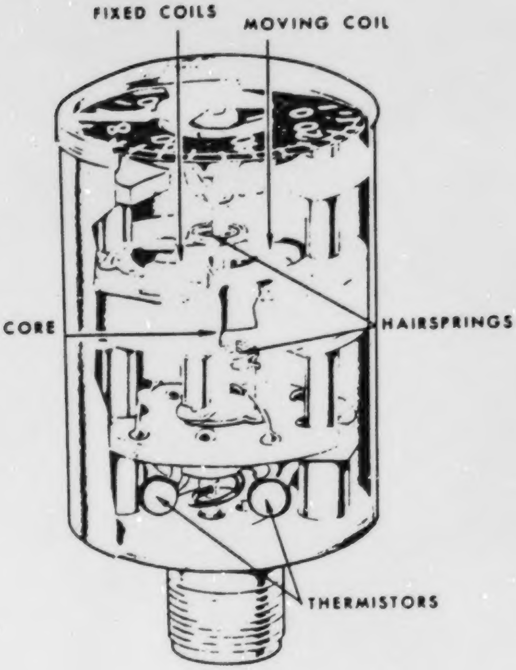

FIXED COILS
MOVING COIL
CORE
HAIRSPRINGS
THERMISTORS

Figure 22.

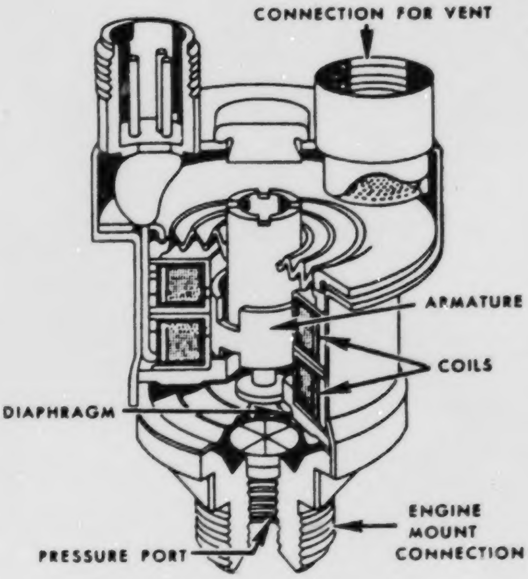

CONNECTION FOR VENT
ARMATURE
COILS
DIAPHRAGM
ENGINE MOUNT CONNECTION
PRESSURE PORT

Figure 23.

Circle the letter of the correct response to the following statement.

1. The purpose of the variable reluctance pressure system is to measure engine oil pressure in

   a. inch pounds.
   b. foot pounds.
   c. pounds per square inch.
   d. pounds per square foot.

Frame 2

The variable reluctance pressure indicator is essentially a dynamometer type, moving coil, AC voltmeter that indicates engine oil pressure, in pounds per square inch. Figure 24 shows a cutaway view of the indicator. The dynamometer type meter movement is very similar to the D'Arsonval meter movement that you have studied earlier. The main difference is the permanent magnet used in the D'Arsonval meter movement is replaced by fixed coils, that serve as electromagnets. These electromagnets will change polarity every half cycle. By replacing the permanent magnets with electromagnets, the meter movement will measure AC voltage without requiring a rectifier circuit. The moving coil is wound so that its magnetic polarity is the same polarity as the fixed coils for the same half cycle of AC.

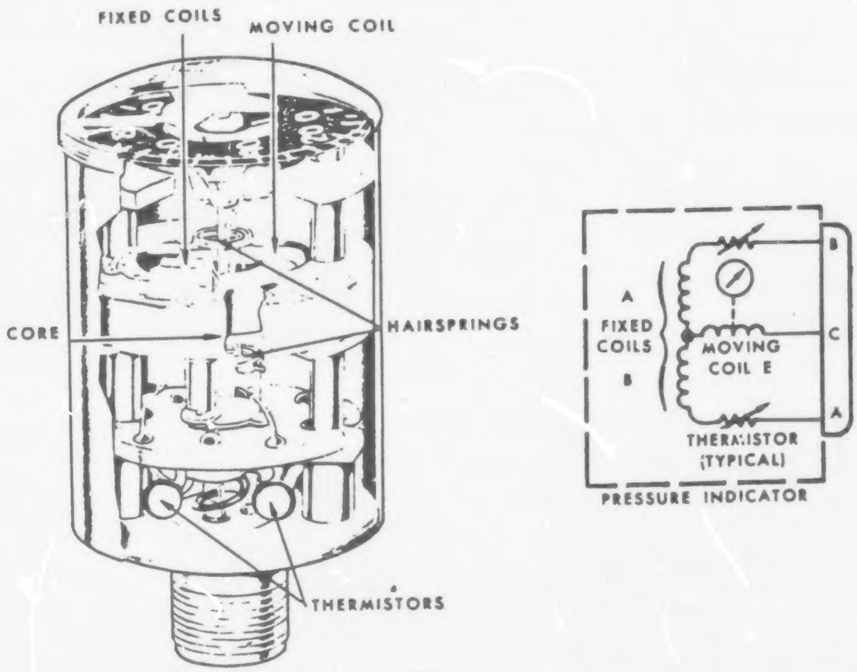


Figure 24.

Circle the letter of the correct response to the following statement.

1. The variable reluctance pressure indicator can measure AC voltage

   a. with the aid of a rectifier.
   b. without the aid of a rectifier.
   c. with the aid of a rectifier and electromagnets.

2. The purpose of the fixed coils is to

   a. serve as electromagnets.
   b. change polarity every full cycle.
   c. change polarity every TWO cycles.

3. Magnetic polarity between the fixed coils and the moving coil

   a. stays the same every half cycle.
   b. changes in the fixed coils and stays the same in the moving coil every half cycle.
   c. changes in the moving coil and stays the same in the fixed coils every half cycle.

Answer to Frame 1: 1. c

Frame 3

Two of the laws of magnetism state that like poles repel each other and unlike poles attract each other. When the magnetic field of the moving coil is placed inside the magnetic field of the fixed coils, the fields attempt to align themselves. It is the interaction of these magnetic fields that cause thy meter pointer to be deflected. When no current is flowing through the coils, no magnetic field is present around the coils; therefore the movig coil does not move and the pointer stays at zero due to tension exerted by the hairspring.

NO RESPONSE REQUIRED

Answers to Frame 2: 1. b 2. a 3. a

The pointer of the indicator is returned to zero by the tension of the hairsprings. Notice in figure 24 that the moving coil is mounted in the center of the fixed coils. The moving coil is free to rotate within the fixed coils and has the pointer of the indicator connected to the center shaft. Whenever current flows through the moving coil, the coil rotates because of the interaction of the magnetic fields. As the moving coil rotates, it moves thy pointer up-scale. The core, shown in figure 24, aids in containing the magnetic field of the fixed coils and prevents external magnetic fields from causing errors in the indicator. The thermistors keep current in the circuit stable regardless of temperature changes.

Circle the letter of the correct response to the following statements.

1. The purpose of the hairspring is to

   a. conduct current to the moving coil.
   b. return the pointer to zero.
   c. help rotate the pointer to a higher reading.

2. The moving coil will react and rotate when current flows through the

   a. coil.
   b. hairsprings.
   c. fixed coils.

3. The purpose of the core is to aid in containing the field of the

   a. rotating coil.
   b. fixed coils.
   c. rotating coil and fixed coils.

4. The purpose of the thermistors is to keep

   a. current stable in the circuit.
   b. voltage stable in the circuit.
   c. reluctance stable in the circuit.

Frame 5

The variable reluctance pressure transmitter consists basically of a pressure sensing diaphragm, two coils, an armature, and a compensating diaphragm. These units are used to measure the differential pressure between the oil pump output and atmospheric or internal engine pressure. These components are housed in a sealed case and cannot be replaced. An opening in the top of the transmitter allows adjustment of the transmitter on the bench. A cutaway drawing of a typical transmitter is shown in figure 25.

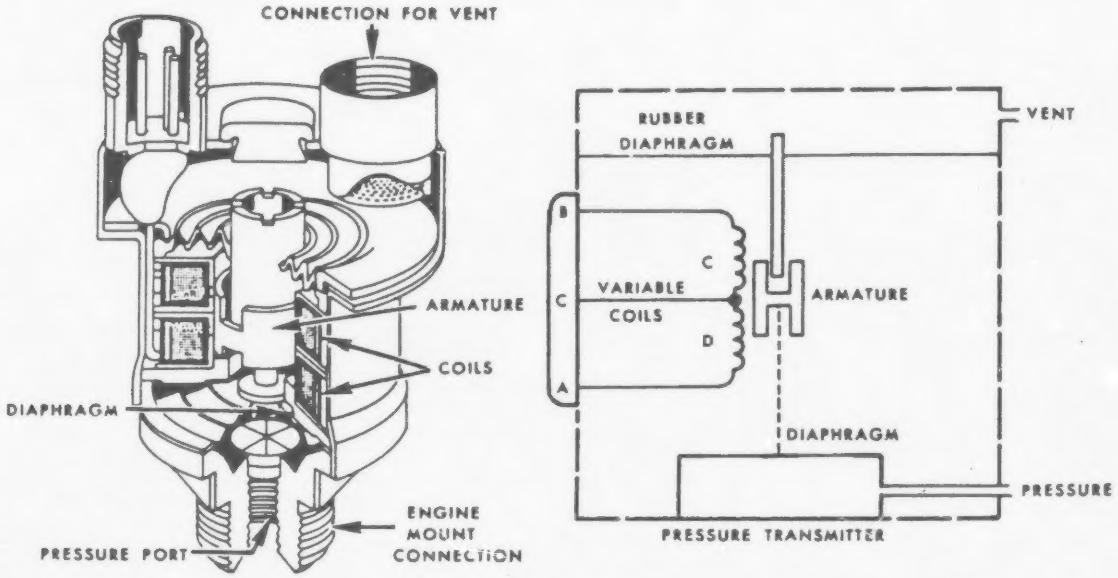

CONNECTION FOR VENT
ARMATURE
COILS
DIAPHRAGM
ENGINE MOUNT CONNECTION
PRESSURE PORT
VENT
RUBBER DIAPHRAGM
B
C
VARIABLE COILS
C
D
A
ARMATURE
DIAPHRAGM
PRESSURE
PRESSURE TRANSMITTER

Figure 25.

Circle the letter of the correct response to the following statement.

1. The transmitter contains the sensing elements that measure

    a. absolute engine pressure.
    b. absolute atmospheric pressure.
    c. difference in pressure between the oil pump output and atmospheric pressure.

Answers to Frame 4: 1. b 2. a 3. b 4. a

The vent connection shown on top of the transmitter in figure 25 is usually connected to atmospheric or engine internal pressure. This pressure is applied directly to the compensating diaphragm. This diaphragm senses any change in atmospheric or internal engine pressure and reacts on the armature. The transmitter measures the differential pressure between the oil pump output and the reference pressure connected to the vent connection.

Refer to figure 25 to answer the following questions. Circle the letter(s) of the correct response to the following statements.

1. The purpose of the compensating diaphragm is to detect a change

   a. in oil pressure.
   b. of inductance in the coils.
   c. in atmospheric or internal engine pressure.

2. The differential pressure between the oil pump output and the reference pressure is sensed by the

   a. oil pressure gage.
   b. compensating diaphragm.
   c. oil pressure diaphragm.
   d. oil pressure transmitter.

Answer to Frame 5: 1. c

Frame 7

The transmitter operates on the principle of varying the reluctance to the magnetic lines of flux surrounding the coils within the transmitter. From your study of coils you should remember that the inductance of a coil can be changed by providing a path of high or low reluctance to the magnetic lines of flux surrounding the coil. One way to accomplish this is to insert a soft iron core called an armature, into the center of the coil. This core or armature provides an easier path for the magnetic lines of flux than an air core. The amount of reluctance change depends on the permeability of the material and how far the material is inserted into the coil. See figure 25.

Circle the letter of the correct response to the following statements.

1. The transmitter coils produce magnetic lines of flux when

   a. current is flowing in the coils.
   b. no current is flowing in the coils.
   c. current is flowing in the armature.
   d. no current is flowing in the armature.

2. The armature or core that provides the path of lowest reluctance is

   a. an air core.
   b. a copper core.
   c. a soft iron core.
   d. an aluminum core.

Answers to Frame 6: 1. c 2. d

Frame 8

Notice in figure 26 that the armature is connected to the pressure-sensing diaphragm at the bottom of the transmitter. When pressure is sensed by the diaphragm, the diaphragm expands and changes the armature position within the coils. The armature is moved inside the coils. It offers an easier path for the magnetic lines of flux than the path offered by the air gap. This path of low reluctance provided by the armature causes the inductive reactance (ohms) of the coils to vary with the armature position.

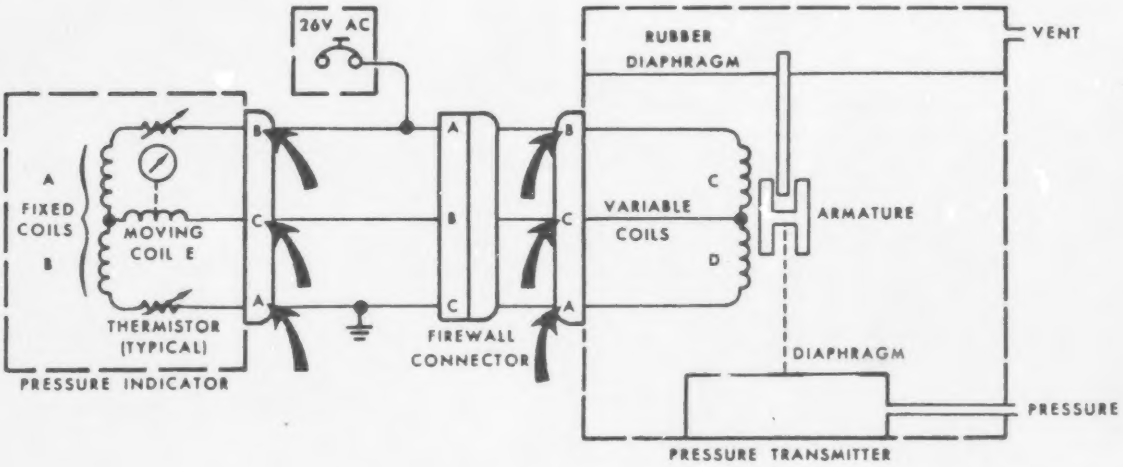

26V AC
RUBBER DIAPHRAGM
VENT
A
FIXED COILS
B
MOVING COIL E
THERMISTOR (TYPICAL)
PRESSURE INDICATOR
B
C
A
A
B
C
FIREWALL CONNECTOR
B
C
A
C
VARIABLE COILS
D
ARMATURE
DIAPHRAGM
PRESSURE
PRESSURE TRANSMITTER

Figure 26.

Refer to figure 26 to answer the following questions. Circle the letter of the correct response to the following statements.

1. As oil pressure increases, the pressure diaphragm will cause the

   a. coils to move.
   b. armature to rotate.
   c. armature to move up.
   d. armature to move down.

2. As the armature moves down, the inductive reactance of

   a. coil C becomes greater.
   b. coil D becomes greater.
   c. coil D becomes less.
   d. both coils stay the same.

Answers to Frame 7: 1. a 2. c

645

Frame 9

The electrical units of the variable-reluctance system are connected to form an AC bridge circuit. See figure 26. The 26VAC power is applied through pin "B" of the transmitter and indicator electrical connectors. Pins "A" of the electrical connectors serve as the common ground for the circuit while pins "C" serves as the signal carrying lead.

Circle the letter of the correct response to the following statement.

1. Basically when electrically connected, the variable-reluctance pressure system forms

   a. a series-parallel circuit.
   b. an AC bridge circuit.
   c. a variable-resistive circuit.

Answers to Frame 8: 1. c 2. b

666

Electrically, the fixed coils A and B of the indicator are connected in series, see figure 26. They both have the same inductive reactance or opposition to current flow. From your studies of electrical circuits, you should be able to see that fixed coils A and B will drop the applied AC voltage equally. For example, the applied voltage, shown in figure 26, is 26VAC. Thus, fixed coils A and B will have an equal voltage drop of 13 volts.

Refer to figure 26 to answer the following questions. Circle the letter of the correct response to the following statements.

1. Coils A and B are connected in
   a. series.
   b. parallel.
   c. series-parallel.

2. Since both coils A and B have the same amount of inductive reactance, the voltage drop across the coils will be
   a. the same.
   b. more across coil "A".
   c. more across coil "B".

Answer to Frame 9: 1. b

Frame 11

Electrically, the variable coils C and D of the transmitter are connected in series. See figure 27. Both of these coils have the same inductive reactance or opposition to current flow as long as the armature is centered. The applied voltage, shown in figure 27, is 26VAC. Since the coils are connected in series and each one has the same inductive reactance, the voltage drop across each coil is approximately 13 volts. For ease of explanation we will disregard the small voltage drop across the thermistors. When the indicator is connected to the transmitter, an AC bridge circuit is formed. When the voltage drops across coils A, B, C, and D are equal, the bridge circuit is balanced, and no current will flow through moving coil E. At this time, the pointer of the indicator is on zero.

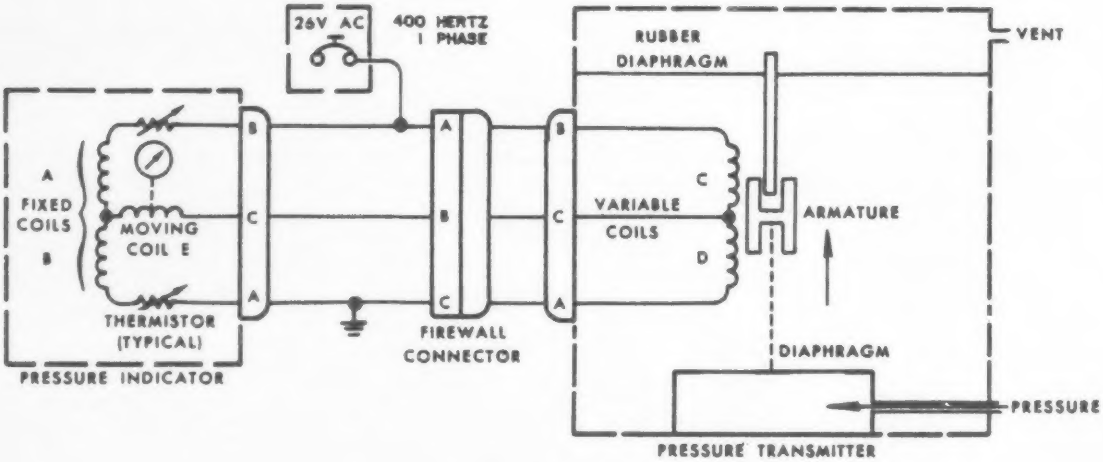

26V AC
400 HERTZ
1 PHASE
RUBBER
DIAPHRAGM
VENT
A
FIXED
COILS
B
MOVING
COIL E
THERMISTOR
(TYPICAL)
PRESSURE INDICATOR
B
C
A
A
B
C
FIREWALL
CONNECTOR
B
C
A
VARIABLE
COILS
C
D
ARMATURE
DIAPHRAGM
PRESSURE
PRESSURE TRANSMITTER

Figure 27.

Refer to figure 27 to answer the following questions. Circle the letter of the correct response to the following statements.

1. With the armature centered as shown in figure 27, the voltage drop across coils C and D is

   a. 13 volts on each coil.
   b. 10 volts on coil C and 16 volts on coil D.
   c. 16 volts on coil C and 10 volts on coil D.
   d. 14 volts on coil C and 12 volts on coil D.

2. When the indicator and transmitter are electrically connected, they form

   a. a DC bridge circuit.
   b. a parallel circuit.
   c. an AC bridge circuit.
   d. a series-parallel circuit.

Answers to Frame 10: 1. a 2. a

When pressure is applied to the pressure diaphragm of the transmitter, the armature will move. See figure 27. The arrows represent an increase in pressure and will affect the direction that the armature moves. Since the armature is made of a material that has a low reluctance, the movement of the armature causes the inductive reactance of coils C and D to change. The voltage drops across coils C and D are no longer equal, and the bridge circuit is unbalanced. Current will now flow through moving coil E, causing the pointer of the indicator to move up-scale.

Refer to figure 27 to answer the following questions. Circle the letter of the correct response to the following statements.

1. As the armature is moved upward, the inductive reactance will

   a. increase in coil D.
   b. increase in coil C.
   c. stay the same in both coils.
   d. decrease in coil C.

2. As inductive reactance increases (figure 27), voltage drop will

   a. decrease across coil D.
   b. decrease across coil C.
   c. stay the same in coil C and coil D.
   d. increase across coil D.

3. The voltage requirement for the oil pressure indicating system is

   a. 26-volts DC.
   b. 26-volts AC, 400-Hertz, single-phase
   c. 26-volts AC, 400-Hertz, three-phase.

Answers to Frame 11: 1. a 2. c

Frame 13

To show how the system works, let's use a case; when the armature has moved upward enough to cause the voltage drop across the variable coil "C" to increase. Since the armature is also having an effect on coil "D", the voltage drop across coil "D" goes down. Now, let us assign polarities to the voltage drops across the coils in the circuit for a given half cycle or applied AC. On the positive half cycle, the voltage drops across the coils are as follows: Coil "A" - 13 volts, coil "B" - 13 volts, coil "C" - 16 volts, and coil "D" - 10 volts.

See figure 28: Under these conditions, current will flow through the moving coil "E". The reason being that the top of coil "B" is at a +13 volt potential, while the top of coil "D" is at a +10 volt potential in reference to ground. Since a +10 volts is less positive than +13 volts, current flows from the +10 volt potential to the +13 volt potential through the moving coil "E" in the indicator causing the pointer to move UP-SCALE.

On the negative half-cycle of the applied AC all the polarities of the coils reverse. However, the voltage drops across the coils do not change unless the armature is repositioned as a result of a pressure change. See figure 28.

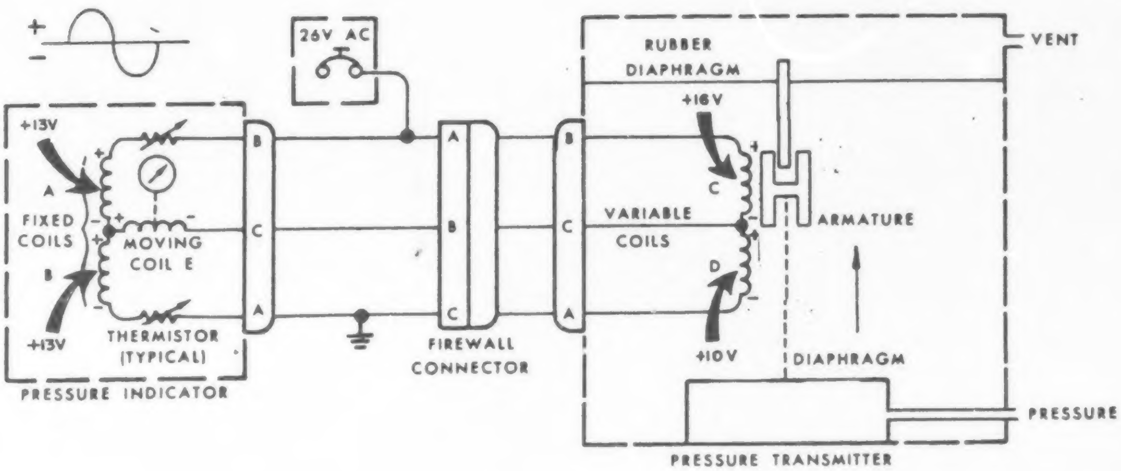

+
-
26V AC
RUBBER
DIAPHRAGM
VENT
+13V
+
A
FIXED
COILS
-
+
+
-
MOVING
COIL E
B
-
+13V
THERMISTOR
(TYPICAL)
PRESSURE INDICATOR
B
C
A
A
B
C
FIREWALL
CONNECTOR
B
C
A
+16V
+
C
VARIABLE
COILS
-
+
D
-
+10V
ARMATURE
DIAPHRAGM
PRESSURE
PRESSURE TRANSMITTER

Figure 28.

Refer to figure 28 to answer the following questions. Circle the letter for the correct response to the following statements.

1. In figure 28, current flows from the top of
   - a. coil "A" to top of coil "C".
   - b. coil "B" to top of coil "D".
   - c. coil "D" to top of coil "B".
   - d. coil "E" to top of coil "C".
2. On the negative half-cycle,
   - a. all polarities reverse.
   - b. voltage drops across coils change.
   - c. the armature is repositioned.

Answers to Frame 12: 1. b 2. a 3. b

Answers to Frame 13: 1. c 2. a

Return to the beginning of this programmed text and review the objectives. When you are satisfied that you know and understand the material you will take an appraisal. After passing the appraisal you will proceed to the LAB to perform on an actual variable reluctance pressure system.

APPRAISAL

WORKBOOK

3ABR32531-WB-203
3ABR32632B-WB-303

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

PRESSURE INDICATING SYSTEMS

12 July 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-203
3ABR32632B-WB-303

INSPECTION, OPERATIONAL CHECK, TROUBLESHOOTING AND BENCH CHECK OF THE PRESSURE INDICATING SYSTEMS

SPECIAL INSTRUCTIONS

WB 203/303 is written in three sections. Section A provides an outline for performing the Inspection, Operational Check and Bench Check of the Direct Reading Pressure System. Section B provides an outline for performing the Inspection, Operational Check, Troubleshooting and Bench Check of the Synchro Pressure Indicating System. Section C provides an outline for performing the Inspection, Operational Check and Troubleshooting of the Variable Reluctance Indicating System.

OBJECTIVES

Given a workbook, tools, test equipment, and trainers, perform an inspection and operational check of pressure indicating systems with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainers, troubleshoot pressure indicating systems with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainers, bench check components of pressure indicating systems with an accuracy of 100% correct workbook responses.

SECTION A DIRECT PRESSURE

EQUIPMENT

	Basis of Issue
3ABR32531-WB-203, 3ABR32632B-WB-303	1/student
Direct Reading Pressure Gage (Meter Cabinet)	1/student
Dead Weight Tester P/N #10-10525	1/student
TO 33A6-4-7-1 EXTRACT	1/student
Wrenches (1" x 3/4")	2/student

PROCEDURE

Remove ALL JEWELRY before starting to work. Observe ALL safety precautions. Follow the instructions in the workbook and technical order extracts. Place a checkmark (√) in the appropriate blank. The TO EXTRACTS are attached to the back of this workbook.

Supersedes 3ABR32531-WB-207, 21 August 1974; 3ABR32531-WB-208, 3ABR32632B-WB-306, 14 August 1974, which may be used until existing stocks are exhausted.
OPR: 3360TTG
DISTRIBUTION: X
3360TTGTC-W - 300: TTVSR - 1

PART I INSPECTION

Using the chart below, place a checkmark (√) in the appropriate box according to your findings.

INSPECT GAGE FOR:

		S	U
1. Clean cover glass	1.		
2. Broken or cracked cover glass	2.		
Range markings for:			
3. Intact	3.		
Specific limits			
4. Red Radial - 35 PSI MIN. OPERATION	4.		
5. Green Arc - 40 - 70 PSI NORMAL OPERATION	5.		
6. Red Radial - 80 PSI MAX. OPERATION	6.		
7. Discoloration (faded) Dial	7.		
8. Index (slippage) mark for alignment	8.		
9. Vent hole open and free of any obstruction	9.		

VISUAL INSPECTION CHART

Note: If you check any item in the unsatisfactory column, state what should be done to correct this condition.

____

____

PART II OPERATIONAL CHECK

Where applicable, make a checkmark (√) in the column under S or U in accordance with your findings.

1. Perform an operational check of the Oil Pressure Indicating System using the Dead Weight Test PN 10-10525, Direct Pressure Gage and read the information contained in TO EXTRACT 33A6-4-7-1 that has been outlined with a heavy black line.

2. Remove large plug from tester and plastic cap from pressure gage and connect the pressure gage finger tight to the deadweight tester.

Note: Do not twist the pressure gage onto the deadweight tester. Turn the coupling nut onto the pressure gage.

3. Position the gage so that it is level and you can read the dial.

4. Using the two large wrenches: Hold the pressure gage with one wrench and tighten the nut with the other wrench.

5. Apply enough weight to the platform of the deadweight tester to equal an 80 psi reading - weights to equal 75 pounds plus the 5 pounds of the low pressure piston being used.

6. Relief valve on the tester should be closed. Plug should be loosened (NOT ALL THE WAY OUT).

Caution: Never apply any more pressure than is required to support the weight on the piston platform.

7. Using the handle on the tester, pump up tester and slowly rotate the weight on the platform, raise it 1/2 inch, then observe the gage reading.

8. Pointer on gage should have moved upscale without showing effects of binding as the pump handle was operated.

9. Gage should read 80 (± 3 psi). Indication is satisfactory______, unsatisfactory______.

10. Relieve the pressure on the tester and gage by slowly opening the relief valve.

11. Pointer on gage should return to zero (0 ± 3) psi. Indication is satisfactory______, unsatisfactory______.

Caution: Make sure that pressure has been relieved before removing weights from piston platform.

Note: If 3ABR32632B student: Remove weights, disconnect pressure gage from tester and return wrenches and pressure gage to meter cabinet. Clean UP Deadweight Tester.

12. Leave gage and piston on tester, but return weights to the box.

PART III

BENCH CHECK

Using the deadweight tester apply weights to obtain the various readings on the gage plus or minus tolerances. For "friction error" the "before tap" reading can vary by a plus or minus (±) 2 psi from the "after tap" reading on all checks. The "after tap" reading is where the gage is read for "scale error" and should agree with the test weight applied plus or minus the tolerance shown in the Scale Error Column shown below.

FRICTION AND SCALE ERROR CHART

TEST WEIGHTS	Friction Error				Scale Error		
	BEFORE TAP	AFTER TAP	S	U		S	U
0 PSI					0 ± 3 PSI		
50 PSI					50 ± 3 PSI		
100 PSI					100 ± 5 PSI		
150 PSI					150 ± 5 PSI		
200 PSI					200 ± 5 PSI		

Note: This type of gage can be checked at its maximum pressure reading without any harmful effect to the gage.

1. If an ERROR was found in the gage, take another look at the figures in the Friction and Scale Error chart and the troubleshooting chart (pages 6 and 7). List the trouble and all the possibilities that could cause the particular trouble in the spaces below.

Trouble found:

1.

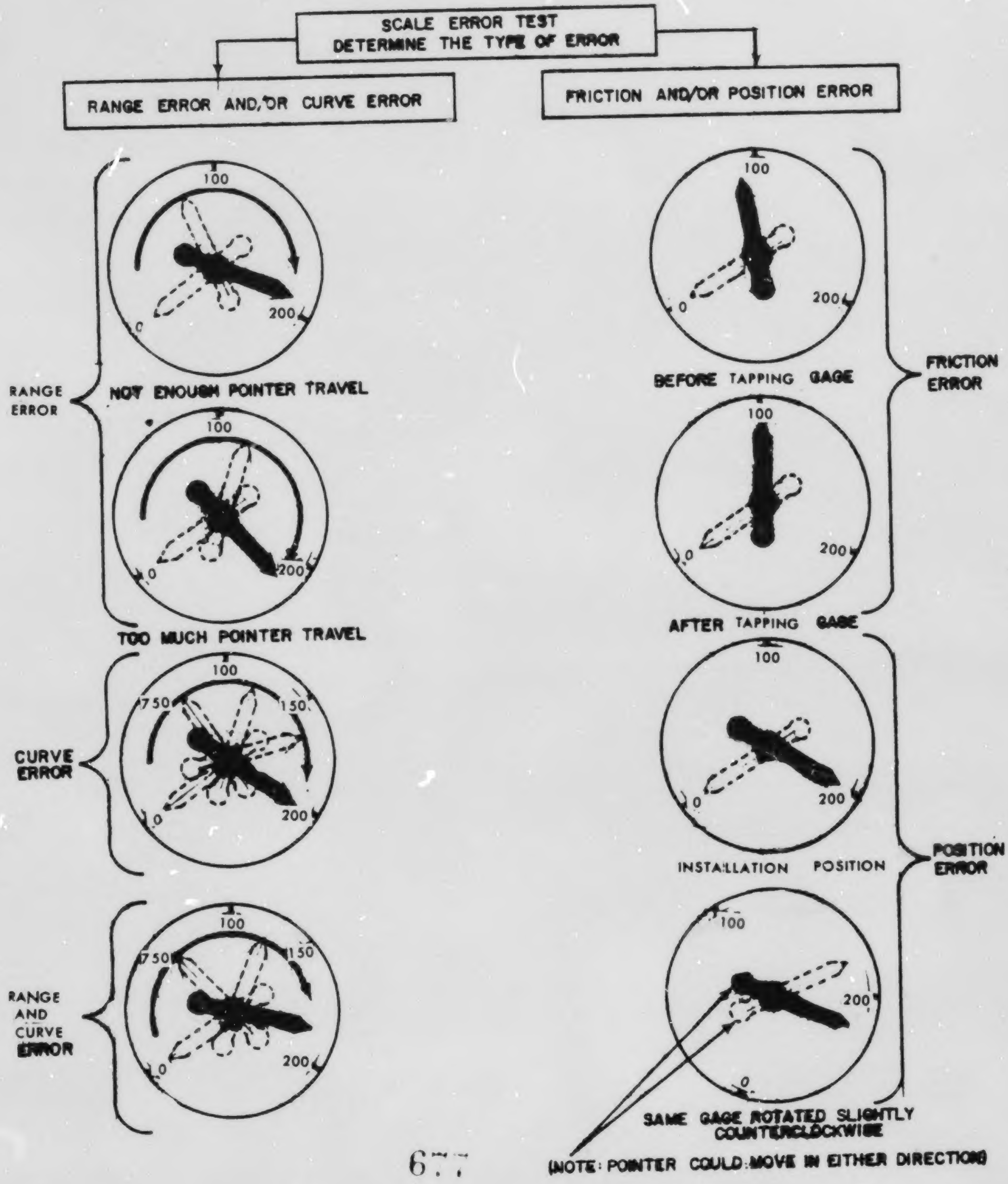
2.

Possible cause(s) of trouble:

1.

2.

3.


SCALE ERROR TEST
DETERMINE THE TYPE OF ERROR
RANGE ERROR AND/OR CURVE ERROR
FRICTION AND/OR POSITION ERROR
100
200
0
NOT ENOUGH POINTER TRAVEL
RANGE ERROR
TOO MUCH POINTER TRAVEL
750
150
CURVE ERROR
RANGE AND CURVE ERROR
BEFORE TAPPING GAGE
AFTER TAPPING GAGE
FRICTION ERROR
INSTALLATION POSITION
POSITION ERROR
SAME GAGE ROTATED SLIGHTLY COUNTERCLOCKWISE
(NOTE: POINTER COULD MOVE IN EITHER DIRECTION)

Types of Errors

DIRECT READING PRESSURE GAGE TROUBLESHOOTING CHART

TROUBLE	PROBABLE CAUSE	REMEDY
Gage does not register.	Fractured Bourdon tube.	Replace socket assy.
	Broken Link.	Replace socket assy.
	Pointer loose on staff.	*Reset pointer.
	badly damaged or corroded movement.	Replace movement.
Pointer fails to return to zero position.	Foreign matter in Bourbon tube.	Replace socket assy.
	Bourdon tube stretched.	*Reset pointer.
Does not register properly.	Faulty mechanical adjustment.	Readjust (calibrate).
	Worn teeth (sector and pinion) in movement.	Replace movement.
	Leaking Bourdon tube.	Replace socket assy.
Gage fails to register full dial reading.	Range error.	Adjust movement.
	Excessive friction.	Replace movement.
	Dirt in movement.	Clean.
Gage sticking.	Badly worn or bent movement.	Replace movement.
	Scale or foreign matter in Bourdon tube.	Replace socket assy.
	Dirt in movement.	Clean.
	Corroded movement.	Clean or replace.
	Pointer bent. Rubs on dial, dial screws or glass.	*Straighten pointer.

The entire mechanism (collectively) is referred to as the socket assembly.

*This is the only type of maintenance that can be performed on this particular type gage by an activity below Depot level maintenance.

2. Remove the weights from the tester and place them back in the proper rack.

3. Disconnect the tester from the pressure gage.

4. Install plug to deadweight tester and plastic cap to pressure gage.

5. Clean ALL hydraulic fluid from the tester and bench top.

6. Return the wrenches and pressure gage to the meter cabinet.

7. Turn IN workbook to instructor.

8. Sign your last name on the cover of the workbook.

SECTION B SYNCHRO PRESSURE

EQUIPMENT

	Basis of Issue
3ABR32531-WB-203, 3ABR32632B-WB-303	1/student
Engine Instrument Trainer #2951	1/student
Deadweight Tester P/N #10-10525	1/student
Test Set Field Synchro #131819-2A	1/student
Multimeter	1/student
TO 5L6-2-4-3 EXTRACT	1/student
TO 5P5-3-1-73 EXTRACT	1/student
TO 33D2-6-105-1 EXTRACT	1/student
TO 33A6-4-7-1 EXTRACT	1/student
Wrenches (1" x 3/4")	2/student

PROCEDURE

Remove ALL JEWELRY before starting to work. Observe ALL safety precautions. Follow the instructions in the workbook and Technical Order EXTRACTS. Place a checkmark (✓) in the appropriate blank. The TO EXTRACTS are attached to the back of this workbook.

PART I INSPECTION

1. Visually inspect the oil pressure indicator for:

	Satisfactory	Unsatisfactory
a. Cracked or broken glass.		
b. Dented or cracked case.		
c. Fluorescent markings on dial.		
d. Bent or broken dial pointer.		
e. Damaged electrical connector.		
f. Security of mounting of indicator.		

2. Visually inspect the electrical wiring for:

	Satisfactory	Unsatisfactory
a. Frayed or broken wires.		
b. Damaged or broken electrical connector plug.		
c. Frayed or broken insulation.		
d. Security of mounting of wires.		

3. Visually inspect the oil pressure transmitter for:

	Satisfactory	Unsatisfactory
a. Dented or cracked case.		
b. Damaged electrical connector.		
c. Damaged oil fitting.		
d. Security of mounting.		

PART II OPERATIONAL CHECK

1. Perform an operational check of the Synchro Oil Pressure Indicating System using the deadweight tester. Refer to TO 33A6-4-7-1 EXTRACT to perform operational check.

Caution: Do Not cross thread the NUT.

2. Connect the deadweight tester to the synchro oil pressure transmitter (finger tight). Tighten fitting so that it does not leak - use TWO large wrenches provided. Use the low pressure piston and weights for this test.

3. Connect the trainer to 26V AC 400 Hz power source, push in the circuit breaker and turn ON the switches (Oil Pressure and 26V AC 400 Hz).

Warning: Do NOT place large weignts on top of the small weights, and the pressure MUST be relieved on the deadweight tester before weights are removed.

Note: When pumping up tester, be sure to rotate weights slowly to prevent binding of the piston

4. With the tester relief valve open and NO weights on tester, the indicator should indicate 0 psi.

Note: Tolerance is ± 4 psi for all readings in steps 4 through 8.

Tap transmitter before taking readings.

	PSI	Satisfactory	Unsatisfactory
0 psi indicator check			

5. Close relief valve on tester and place 50 pounds of weights on tester and pump up pressure until weights are raised slightly. Indicator should indicate 50 psi.

	PSI	Satisfactory	Unsatisfactory
50 psi indicator check			

6. Open relief valve and increase weights to 100 pounds. Pump up pressure until weights are raised slightly. Indicator should indicate 100 psi.

	PSI	Satisfactory	Unsatisfactory
100 psi indicator check	______	____________	______________

7. Open relief valve and increase weights to 150 pounds and pump up pressure until weights are raised slightly. Indicator should indicate 150 psi.

150 psi indicator check	______	____________	______________

8. Open relief valve and increase weights to 200 pounds. Pump up pressure until weights are raised slightly. Indicator should indicate 200 psi.

200 psi indicator check	______	____________	______________

PART III TROUBLESHOOTING

1. Relieve pressure on tester and place trouble switch #5 to the IN position. Reduce weights to 150 pounds.

2. Close relief valve on tester and pump up pressure until weights are raised slightly, while observing the indicator.

The oil pressure reading is high______, low______, erratic______, last indication (inoperative)______.

3. Open relief valve on tester to relieve pressure on transmitter.

4. Place trouble switch #5 to the OUT position and place trouble switch #6 to the IN position.

5. Close relief valve on tester and pump up tester until weights are raised slightly, while observing indicator. Then release pressure while observing indicator.

The oil pressure reading is high______, low______, erratic______, last indication (inoperative)______.

6. Place trouble switch #6 to the OUT position.

7. Turn OFF switches on trainer and pull circuit breaker.

Note: Have instructor check trouble indications.

8. Disconnect trainer from 26V AC power source.

9. Disconnect the electrical connector plugs from the transmitter and indicator.

10. Connect the test leads to your multimeter and zero the meter.

11. Place trouble switch #5 to the IN position.

a. The location of the trouble is wire number ________________.

b. The trouble is a short_____, open_____, crossed wires_____.

12. Place trouble switch #5 to the OUT position and place trouble switch #6 to the IN position.

a. The location of the trouble is wire number ________________.

b. The trouble is a short_____, open_____, crossed wires_____.

13. Place trouble switch #6 to the OUT position.

Note: If 3ABR32632B student: Connect up transmitter and indicator electrical connector plugs, disconnect deadweight tester, and clean up tester. Disconnect leads from meter and stow meter and leads in cabinet.

PART IV BENCH CHECK

1. Using the following procedures perform a resistance check of the transmitter. Reconnect electrical connector plug to transmitter ONLY.

2. Refer to EXTRACT of TO 5P5-3-1-73, Section III, paragraph 3-6, and figure 3-2, for the resistance check of the transmitter. Use the multimeter for this check and refer to tolerances.

a. Using the following test points for the transmitter, read and record the ohmmeter readings on the blanks provided.

(1) Test points A-D, Ohms_______.

(2) Test points D-C, Ohms_______.

(3) Test points A-C, Ohms_______.

b. Using the test points listed below, read and record the ohmmeter reading for the transmitter rotor.

(1) Test points A-B, Ohms_______.

c. The transmitter is satisfactory_____, unsatisfactory_____.

3. Using the following procedures perform a Friction and Scale Error Check on the transmitter.

4. The following instructions tell how to connect the Synchro Field Tester to the transmitter.

a. Connect the power cable "A" to the Power Input Plug #10 on the tester.

b. Connect the cable "G" (QB86030-1) to Test Unit Plug #9 on tester.

c. Connect the cable "G" to cable "J".

d. Connect cable "J" to transmitter.

e. Plug cable "A" to 115V AC, 400 Hz outlet.

Note: Do NOT turn power switch #17 on at this time.

5. For operation of the Synchro Field Tester for bench testing the Oil Pressure Transmitter, refer to the EXTRACT from TO 33D2-6-105-1, paragraph 4-13d through 4-13i.

a. Paragraph 4-13f Voltage Check

(1) Place the multimeter to the AC volts, 50 scale range.

(2) Check power supply voltages for 26 (± 10%) volts at 18 and 19 binding posts. Actual reading ________.

(3) Check power supply voltage for 10.8 (± 10%) volts at 19 and 20 binding posts. Actual reading ________.

(4) Power supply voltages are satisfactory______, unsatisfactory______.

b. Paragraph 4-13g Amplifier Gain Control

(1) Turn the AMPL GAIN 8 fully clockwise. Allow the servo amplifier to warm up for at least one minute before proceeding.

Note: Decrease Ampl. Gain if pointer oscillates.

c. Refer to the EXTRACT from TO 5P5-3-1-73, Section IV, and chart on next page, which gives the test procedures, test points and tolerances for the transmitter being tested.

Pressure PSI	°ARC	Tolerance °ARC	Friction Error S	Friction Error U	Before Tap	After Tap	Scale Error S	Scale Error U
0	20	4.8°						
50	100	4.8°						
EZ 100	180	6.4°						
150	260	6.4°						
200	340	6.4°						

Friction and Scale Error.

d. The transmitter is satisfactory______, unsatisfactory______.

6. Turn power switch #17 to the OFF position.

7. Relieve the pressure on the deadweight tester.

8. Remove the weights and place them back in the rack.

9. Disconnect the deadweight tester from the transmitter and CLEAN UP any spilled oil.

10. Disconnect the lead from the transmitter, and connect it to the indicator and turn power switch #17 to the ON position.

11. Refer to the EXTRACT from TO 33D2-6-105-1, Section IV, paragraph 4-7 through paragraph 4-8 for bench check of the oil pressure indicator.

Note: If you look carefully at the synchro indicator, you will notice that the 100 psi mark gets narrow toward the outside. This is the Electrical Zero position for this indicator. Para. 4-7 should be done before going to para. 4-8.

12. Refer to EXTRACT of TO 5L6-2-4-3, Section III, paragraph 3-6 through 3-7 and table 3-17 for Bench Test of the Synchro Oil Pressure Indicator.

a. Indicator reads ______ psi ______

b. EZ is satisfactory ______, unsatisfactory ______.

c. Set the SYN IND switch #4 to the CAL position (para. 4-8, TO 33D2-6-105-1).

13. Rotate the knob on the autosyn precision transmitter #1 to obtain test trans. readings, IAW the following chart.

Note: If psi reading is not correct, adjust Trans. #1 to exact° so indicator pointer will read the desired indication listed in chart.

Indicator Psi	Test Trans. Reading Degrees	Before Tap Psi	After Tap Psi	Exact Degrees	Friction Error S	Friction Error U	Scale Error S	Scale Error U
0	20°							
50	100°							
100EZ	180°							
150	260°							
200	340°							

Friction and Scale Error.

a. Friction Error Test is satisfactory ______, unsatisfactory______.
Scale Error test is satisfactory______, unsatisfactory______.

14. Position Error Test

a. Set the Autosyn Precision Transmitter at Mid-Scale (180°). Take a reading with the indicator in a normal horizontal position. This reading should NOT DIFFER from the readings with the indicator in any other position by more than the tolerance of 1/2 degree, by adjusting the Autosyn Precision Transmitter to make indicator read its previous (horizontal) reading.

b. The indicator is satisfactory______, unsatisfactory______.

15. Disconnect the test equipment, stow the leads, and connect electrical connectors on trainer.

16. Put test equipment away and turn in the wrenches to the tool box.

17. Sign last name on cover of workbook.

SECTION C

EQUIPMENT

	Basis of Issue
Variable Reluctance Trainer #4127	1/student
3ABR32531-WB-203, 3ABR32632B-WB-303	1/student
Tester, Deadweight, Part #10-10525	1/student
Multimeter	1/student
Wrenches (1" by 3/4")	2/student

PROCEDURE

Note: Obtain all equipment necessary before starting test.

Place a checkmark (✓) in the appropriate blank.

Refer to TO EXTRACT if necessary.

PART I VISUAL INSPECTION

1. Visually inspect the Variable Reluctance Oil Pressure Indicator for:

	Satisfactory	Unsatisfactory
a. Cracked or loose glass.	__________	__________
b. Condition of fluorescent markings.	__________	__________
c. Condition of pointers.	__________	__________
d. Damaged case.	__________	__________
e. Damaged electrical connector plug.	__________	__________
f. Security ofmounting.	__________	__________

2. Visually inspect the Variable Reluctance Oil Pressure Transmitter for:

a. Damaged case.	__________	__________
b. Damaged electrical connector plug.	__________	__________
c. Oil leaks.	__________	__________
d. Security of mounting.	__________	__________

PART II OPERATIONAL CHECK

1. Using the wrenches connect the Deadweight Tester to the Variable Reluctance Transmitter.

Note: Be careful and do NOT cross thread the fitting.

2. Make sure the trouble switches are to the OUT position.

3. Connect the trainer power cord to the 26V AC 400 Hz outlet.

a. The oil pressure indicator reads off scale low_____, zero_____, off scale high_____.

4. Push the circuit breaker IN.

a. The oil pressure indicator reads off scale low_____, zero_____, off scale high_____.

5. Add 95 pounds of weights to the deadweight tester.

6. Pump up the deadweight tester until the weights are raised slightly.

a. The indicator reads zero_____, 100 psi_____.

PART III TROUBLESHOOTING

1. Relieve the pressure on the tester and reduce weights to 60 psi.

2. Place trouble switch #1 to the IN position. Close valve on the tester and pump up pressure.

a. The indicator indicates 60 psi_____, off scale low_____, off scale high_____.

b. The system is satisfactory_____, unsatisfactory_____.

3. Open valve and bleed down tester. Place trouble switch #1 to the OUT position and place trouble switch #2 to the IN position. Close valve on tester and pump up pressure.

a. The indicator indicates 60 psi_____, off scale low_____, off scale high_____.

b. The system is satisfactory_____, unsatisfactory_____.

4. Open valve and bleed down tester. Place trouble switch #2 to the OUT position and place trouble switch #3 to the IN position. Close valve on tester and pump up pressure.

a. The indicator indicates 60 psi_____, off scale low_____, off scale high_____.

b. The system is satisfactory______, unsatisfactory______.

5. Open valve on the tester and bleed down the pressure. Place trouble switch #3 to the OUT position.

6. Remove weights from the tester and place weights back in the proper rack.

7. Disconnect the power lead from the 26V AC 400 Hz outlet.

8. Pull the circuit breaker.

9. Remove the electrical connector plugs from the indicator and the transmitter.

10. Complete the following chart. Be sure that each trouble switch is to the IN position before troubleshooting that particular trouble.

Trouble Switch	Kind of Trouble (Open, Short, etc)	Wire #
#1	________________	__________________
#2	________________	__________________
#3	________________	__________________

11. Make sure that all trouble switches are to the OUT position.

12. Reconnect the indicator and the transmitter electrical connector plugs.

Note: Bench check NOT to be accomplished by 3ABR32632B students.

PART IV BENCH CHECK

1. Reconnect the power lead to the 26V AC 400 Hz outlet.

2. Push the circuit breaker in.

3. Apply weights to the tester for 40 psi. Close the valve and pump up pressure.

a. The indicator indicates ______ psi.

b. The system is satisfactory______, unsatisfactory______.

Note: If any indicator reading is high or low, enter the reading on the blank and check as unsatisfactory. The tolerance is ± 4 for all readings. Tap indicator before each reading.

4. Open the valve and bleed down tester. Add weights to tester for 60 psi. Close the valve and pump up pressure.

   a. The indicator indicates ______ psi.

   b. The system is satisfactory______, unsatisfactory______.

5. Open the valve and bleed down tester. Add weights to the tester for 80 psi.

   a. The indicator indicates ______ psi.

   b. The system is satisfactory______, unsatisfactory______.

6. Open the valve and bleed down the tester.

7. Remove the weights from the tester and place them back in the proper rack.

8. Disconnect the trainer's power lead from the 26V AC 400 Hz outlet.

9. Disconnect the tester from the trainer.

10. Clean all the oil from around the trainer and the deadweight tester.

11. Remove the leads from the multimeter and put the meter back in the cabinet.

12. Return the wrenches to the tool box.

13. Make sure that you sign your workbook and turn it in to your instructor.

14. Student's Last Name____.

SECTION I
INTRODUCTION AND DESCRIPTION

1-1. IDENTIFICATION.

1-2. This manual contains Operation and Service instructions for the Hydraulic Pressure Gage Dead Weight Tester (FSN 6685-338-2645). This equipment is manufactured by Mansfield & Green, Cleveland 14, Ohio, under their Part Number 10-10525, containing Serial Numbers 1056-6 through 1056-80 and Serial Number 1056-81 and Subsequent. (See assembled views of the equipment.)

1-3. DESCRIPTION.

1-4. PURPOSE. The basic component of the Dead Weight Tester is a twin seal Hydrostatic Test Unit. This unit is a hand operated piston type pump designed specifically for testing of pressure gages. Some of its other uses include setting hydraulic relief valves, pressure switches, hydraulic tubing or piping systems or any pressure operated device. This assembly is designed for operation to 10,000 pounds per square inch.

1-5. CAPABILITIES AND LIMITATIONS. Each unit of equipment consists of a carrying case complete with twin seal pressure test unit, wrenches, gage pointer puller and set assembly, testing attachment (high pressure piston, low pressure piston for Serial Number 1056-6 through Serial Number 1056-80 and a one piece high and low pressure piston for Serial Numbers 1056-81 and Subsequent, dead weight cylinder, offset pipe assembly, high pressure hose assembly) and a complete set of dead weights in separate carrying cases. This equipment will produce pressure in 5 pounds per square inch increments from 5 to 2000 pounds per square inch pressure using the low pressure piston and from 25 to 10,000 pounds per square inch pressure with the high pressure piston.

1-6. GENERAL CONSTRUCTION. The twin seal hydrostatic test unit consists of an oil reservoir, relief valve, vernier valve and handle. The oil reservoir contains the quantity of oil required for building up the necessary pressure to adequately test the various components. The relief valve when closed allows the pressure to build up within the equipment. The vernier valve is used to adjust the pressure after it has been built up to the desired range.

1-7. PRINCIPLES OF OPERATION. In general, the test unit functions similarly to any other hand pump. Operating the hand lever pumps oil from the reservoir to the outlets. When the relief valve is closed, pressure is developed in the pump. Opening the relief valve allows the pressure to decrease and the oil supply to return to the reservoir. Once pressure is built up to the desired range, the vernier valve can be used to accurately adjust the pressure to the desired exact value.

1-8. ATTACHMENTS USED IN CONJUNCTION WITH EQUIPMENT.

1-9. DEAD WEIGHT ATTACHMENT. The dead weight attachment consists of a cylinder for mounting on the twin seal pressure test unit and one low and one high pressure piston for Serial Numbers 1056-6 through 1056-80 and a one piece high and low pressure piston for Serial Numbers 1056-81 and Subsequent.

1-10. DEAD WEIGHTS. The set of dead weights for Serial Numbers 1056-6 through 1056-80, consists of 18 weights as shown in figure 1-1.

1-11. DEAD WEIGHTS. The set of dead weights for Serial Number 1056-81 and Subsequent, consists of 27 weights as shown in figure 1-2.

NOTE

The dead weights are shipped in two separate carrying cases for each series of serial numbers as mentioned in paragraphs 1-10 and 1-11. The dead weights should be kept in these cases when not in use.

PART NUMBER	SIZE (IN. DIA)	NUMBER REQ'D	PRESSURE PRODUCED--PSI		WEIGHT LBS
			LOW PRESSURE	HIGH PRESSURE	
1GT-57	3-1/2	4	5	25	1/2
1GT-58	4	4	20	100	2
1GT-59	5	1	100	500	10
1GT-63-2	8	8	200	1000	20
1GT-63-3	8	1	195	975	19-1/2

Figure 1-1. Table of Dead Weights

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PART NUMBER	SIZE (IN. DIA)	NUMBER REQ'D	PRESSURE PRODUCED--PSI		WEIGHT LBS
			LOW PRESSURE	HIGH PRESSURE	
1GT-205	9	18	100	500	10
1GT-206	9	1	95	475	9-1/2
1GT-207	5	4	20	100	2
1GT-208	3-1/2	4	5	25	1/2

Figure 1-2. Table of Dead Weights

1-12. Each set of dead weights (Serial Numbers 1056-6 through 1056-80) includes one 8 inch diameter weight which produces 195 pounds per square inch pressure with the low pressure piston. The object is to provide an even figure for higher pressures. For example: the high pressure piston (25 PSI) with this weight (975 PSI) totals an even 1000 pounds per square inch.

1-13. Each set of dead weights (Serial Number 1056-81 and Subsequent) includes one 9 inch diameter weight which produces 95 pounds per square inch pressure with the low pressure piston. As explained in the previous paragraphs this will provide an even figure for higher pressures. An example for this group of serial numbers is: the high pressure piston (25 PSI) with this weight (475 PSI) totals an even 500 pounds per square inch.

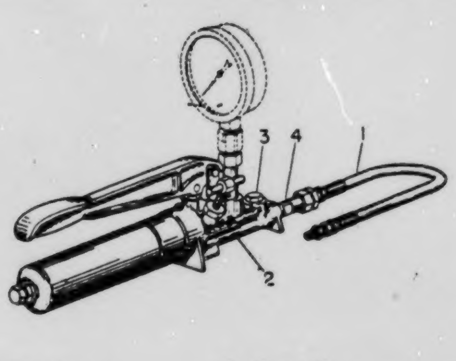
1-14. On each weight two numbers are stamped, indicating the pressure produced. For example, the four inch diameter weights (Serial Numbers 1056-6 through 1056-80) and the five inch diameter weights (Serial Number 1056-81 and Subsequent) are stamped 20 in one place and 100 in another on the upper surface. This indicates that when the low pressure piston is used that the weight produces 20 pounds per square inch pressure and when the high pressure piston is used the same weight produces 100 pounds per square inch pressure.

NOTE

Each weight is stamped with the equivalent pounds per square inch pressure produced. This weight when added to the weight stamped on the platform of the piston equals the total dead weight pressure in pounds per square inch.

1-15. HIGH PRESSURE HOSE ASSEMBLY. (See figure 1-3.) The high pressure hose assembly is supplied with the equipment for use in portable testing. This hose assembly (1) is connected to the end of the twin seal pressure test unit body (2) as shown. The body plug (3) is then installed at the point where the plain nipple union assembly (4) was removed.

1-16. OFFSET PIPE ASSEMBLY. (See figure 4-2.) The offset pipe assembly (1) is attached to the nipple union of the twin seal pressure test unit as shown. The nipple and union attachments of the offset pipe assembly can be used to accommodate the gage fitting being tested. It can be turned and secured in various positions to facilitate ease in handling of the dead weights and observance of the gage under test.



1. Hose Assy
2. Body
3. Body Plug
4. Plain Nipple Union Assy

Figure 1-3. Portable Pressure Testing Arrangement

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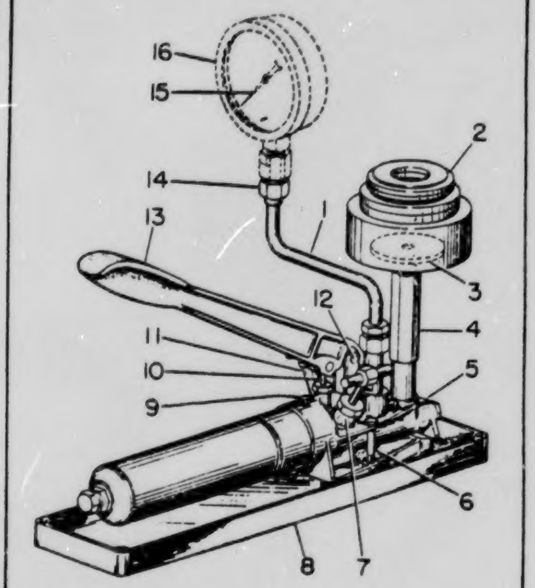
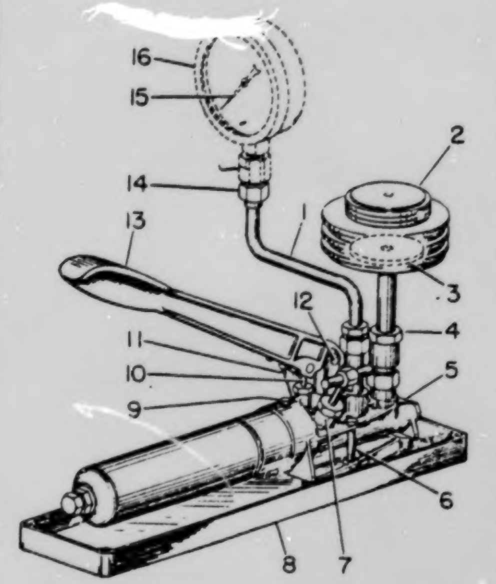


1. Offset Pipe Assy
2. Dead Weight
3. Platform
4. Dead Weight Cylinder
5. Body
6. Bolt
7. Relief Valve
8. Drip Pan
9. Plug
10. Piston Assy
11. Vernier Valve
12. Clevis Pin
13. Handle
14. Union Nut
15. Gage Pointer
16. Gage

Figure 4-2. Setup of Part Number 10-10525 Hydraulic Pressure Gage Dead Weight Tester for Operation (Serial Numbers 1056-6 through 1056-80)



1. Offset Pipe Assy
2. Dead Weight
3. Platform
4. Dead Weight Cylinder
5. Body
6. Bolt
7. Relief Valve
8. Drip Pan
9. Plug
10. Piston Assy
11. Vernier Valve
12. Clevis Pin
13. Handle
14. Union Nut
15. Gage Pointer
16. Gage

Figure 4-3. Setup of Part Number 10-10525 Hydraulic Pressure Gage Dead Weight Tester for Operation (Serial Number 1056-81 and Subsequent)

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piston so that the piston guide is not damaged. When inserting or removing the piston from the unit, rotate it. In this manner scoring of the piston or dead weight cylinder (4) will be prevented. Keep the piston in its protective tube assembly in the carrying case when not in use.

4-10. LOW PRESSURE PISTON. The low pressure piston has the numeral 5 stamped on the platform of the piston, indicating 5 pounds per square inch when using this low pressure piston. This weight stamped on the platform plus the weight stamped on the dead weight equals the total dead weights pressure in pounds per square inch.

CAUTION

Exercise care when handling the low pressure piston so that the piston guide is not damaged. When inserting or removing the piston from the unit, rotate it. In this manner scoring of the piston or dead weight cylinder (4) will be prevented. Keep the piston in its protective tube assembly in the carrying case when not in use.

4-11. DEAD WEIGHTS. Each set of dead weights is listed in figures 1-1 and 1-2. These weights produce pressure in 5 pounds per square inch increments from 5 to 2,000 pounds per square inch using the low pressure piston, and 25 to 10,000 pounds per square inch using the high pressure piston. Paragraphs 1-10 through 1-14 describe the differences in dead weights between the various serial numbers.

WARNING

One person should not attempt to lift or carry the sets of dead weights any distance. Each set weighs approximately 100 pounds.

4-12. OPERATION.

a. Bolt the drip pan (8), figure 4-2 and 4-3, firmly to the bench if permanent location is desired for dead weight testing.

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NOTE

The long drip pan is designed for portable purposes and has an advantage that it will not tip, if not bolted to a bench, when the hand lever is operated.

b. Remove the plain union nipple and mount the dead weight cylinder (4) directly on the pump body (5).

c. Attach the offset pipe assembly (1) to the nipple union by securing with the union nut (14).

d. Place the gage (16) being tested on the other end of the offset pipe assembly and secure.

NOTE

The gage being tested must be at eye level and straight in front of, not sideways to, the operator. Secure when in position as shown in figures 4-2 and 4-3, or as instructed.

e. Insert either the low or high pressure piston (for Serial Number 1056-6 through 1056-80) into the dead weight cylinder as the application may require. For the Serial Numbers 1056-81 and Subsequent the high and low pressure piston is one piece.

NOTE

Each dead weight is stamped with the equivalent of the pounds per square inch produced. When added to the pounds per square inch stamped on the platform of either the low or high pressure piston the total equals the dead weight pressure in pounds per square inch for the gage being tested. See paragraph 4-11 for further description and application.

f. When the relief valve (7) is closed, the pressure is developed in the pump. After pressure has been pumped up with the handle (13) to the approximate pressure desired, the vernier valve (11) is used to obtain the exact pressure. With careful calibration a good test gage can be adjusted to plus or minus one-tenth of one percent of the pressure value.

NOTE

The accuracy of calibration depends on the care of the operator.

g. Weights should be rotated slowly and continuously when pumping up pressure and also when the pressure of the gage being tested has been reached equal to the weights.

CAUTION

The plug (9) should be open when in operation. Close only for refilling reservoir or for storage in carrying case.

h. Pump the unit until the weights plus the platform (3) are raised slightly.

CAUTION

Use care when operating the pump to prevent the pressure from exceeding the maximum reading of either the equipment being tested or the test gage. Tap the case lightly with a finger for accurate reading of a pressure gage.

i. If the gage being tested does not agree with the reading of the total dead weight pressure, remove the threaded bezel ring with glass and using the gage pointer puller and set assembly tool (4, figure 2-2), remove the gage pointer (15, figures 4-2 and 4-3).

NOTE

The gage pointer puller and set assembly tool operates the same as small wheel puller. Placing the pointer puller into position over the gage pointer and turning the hexagon head cap will pull the pointer from the pointer staff.

j. Align the gage pointer on the gage to the proper range point to agree with the total dead weight pressure. Place the drilled end of the tee handle pin (on the pointer puller) at the center of the pointer. Tapping the pin lightly with a small hammer will secure the pointer. Repeat the test until the gage reading agrees with the reading of the total dead weight pressure or as instructed.

k. To stop the equipment, open the relief valve (7) to relieve the oil back to the reservoir, the pressure in the system will then drop to zero.

l. Remove the gage by disconnecting the union nut (14), also remove the union body from the gage. The gage can then be returned to its activity and the parts of the equipment returned to their respective places in the carrying case.

CAUTION

When removing the low or high pressure piston from the unit, rotate piston as it is lifted out. This will prevent scoring of either or both the dead weight cylinder (4) or piston.

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SECTION II

SPECIAL SERVICE TOOLS

(NOT APPLICABLE)

SECTION III

PREPARATION FOR USE, STORAGE, OR SHIPMENT

3-1. PREPARATION FOR USE.

3-2. Unpack the Test Set from the shipping container and swing back the protective cover to see that all the cables listed in figure 1-4 are in the cable storage compartment adjacent to the instrument panel. Make sure that the booklet of calibration tables has been included. Allow sufficient space around the Test Set for connecting the test cables to units under test.

3-3. The Test Set requires a power source of either 115 volts or 26 volts, 400 cps, single phase. Power consumption is approximately 25 watts.

3-4. STORAGE OR SHIPMENT.

3-5. Refer to specification MIL-P-116C for general requirements covering the preservation of equipment against corrosion during shipment and storage.

SECTION IV

OPERATION INSTRUCTIONS

4-1. GENERAL.

4-2. The instructions given in this section refer to the operation of the Test Set, and are not intended to serve as test procedures for the unit under test. When the Test Set is used in an aircraft, the booklet of calibration tables provided will serve as a convenient guide for test values to be obtained from the unit under test. Refer to the applicable technical manual on the unit under test for specific test instructions, test values, and permissible tolerances.

4-3. OPERATING CONTROLS, INDICATORS, AND CONNECTIONS.

4-4. All the operating controls, indicators, and connecting points of the Test Set are illustrated in figure 4-2 and their function is given in figure 4-1. In addition to the items listed, two 1-ampere fuses and one 3/8-ampere fuse are fitted on the instrument panel. Two spare fuses, one for each type, are also included.

4-5. TEST SETUP PROCEDURES.

a. Set all switches and controls to OFF or fully counterclockwise position.

b. Connect test adapter cable QB86030-1 to the TEST UNIT connector on the panel of the Test Set.

CAUTION

Understand the entire operation before starting to test a unit.

4-6. SYNCHRONOUS INDICATOR TEST PROCEDURES.

a. Disconnect the cable from the indicator under test in the aircraft.

b. If a single indicator is to be tested, connect Autosyn Synchro test cable QB84998-1 between test adapter cable QB86030-1 and the indicator. Connect power source cable QB86032-1 to the disconnected aircraft cable and to the POWER-INPUT 10 connector through adapter cable QB86063-1.

c. If a dual indicator is to be tested, connect dual indicator test cable QB86029-1 between test adapter cable QB86030-1 and the indicator. Connect power source cable QB86031-1 to the disconnected

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CONTROL NOMENCLATURE	FUNCTION
Autosyn transmitter 1	Establishes standard against which synchronous and servoed indicators are tested.
TEST SEL switch	Selects the test circuitry for the unit under test. The SYN IND position is used for testing synchronous indicators; the SERVO position is for testing servoed indicators; the MOTOR position is for testing low inertia motors, the TRANS position is for testing transmitters; and the DIFF. position is for testing differentials.
Servoed Autosyn indicator 3	Used as standard for testing accuracy of transmitters and differentials under test.
SYN IND switch 4	Selects the test circuitry for the type of test being performed on synchronous indicators. The E-Z position is used for checking electrical zero, and the CAL position is used when performing calibration tests.
MOTOR VOLTS FXD 5 control	Varies voltage applied to fixed-phase windings of low inertia motors when MOTORS VOLTS switch is in FIXED ø position.
MOTOR VOLTS VAR 6 control	Varies voltage applied to variable-phase windings of low inertia motors when MOTOR VOLTS switch is in VAR ø position.
MOTOR VOLTS 7 switch	Enables monitoring and adjustment of low inertia motor phase voltage at vtvm binding posts.
AMPL GAIN 8 control	Varies gain of servo amplifier in Test Set.
TEST UNIT 9 connector	Provides connection on Test Set to unit under test.
POWER-INPUT 10 connector	Provides connection on Test Set to power source.
POWER 16 lamp	Provides indication that Test Set is energized when POWER Switch is ON.
POWER 17 switch	Controls input power to the Test Set.
26V 18 and 19 binding posts	Provide connection for monitoring test circuits for 26 volts.
10.8V 19 and 20 binding posts	Provides connection for monitoring test circuits for 10.8 volts.
VTVM 21 and 22 binding posts	Provide connections for monitoring motor fixed-phase voltage, variable phase voltage, and servo nulls.

Figure 4-1. Operating Controls, Indicators, and Connections

aircraft cable and to the POWER-INPUT 10 connector through adapter cable QB86063-1.

d. See that aircraft power is on.

e. Set the POWER 17 switch on the Test Set to ON. The POWER 16 lamp should come on, indicating that the Test Set is energized. Using a vtvm or voltohmmeter, check a-c voltages at 26V 18 and 19 binding posts for 26 volts ±10 percent and at 10.8V 19 and 20 binding posts for 10.8 volts ±10 percent.

Note

If the indicator is tested on a test bench rather than in an aircraft, use power source

676

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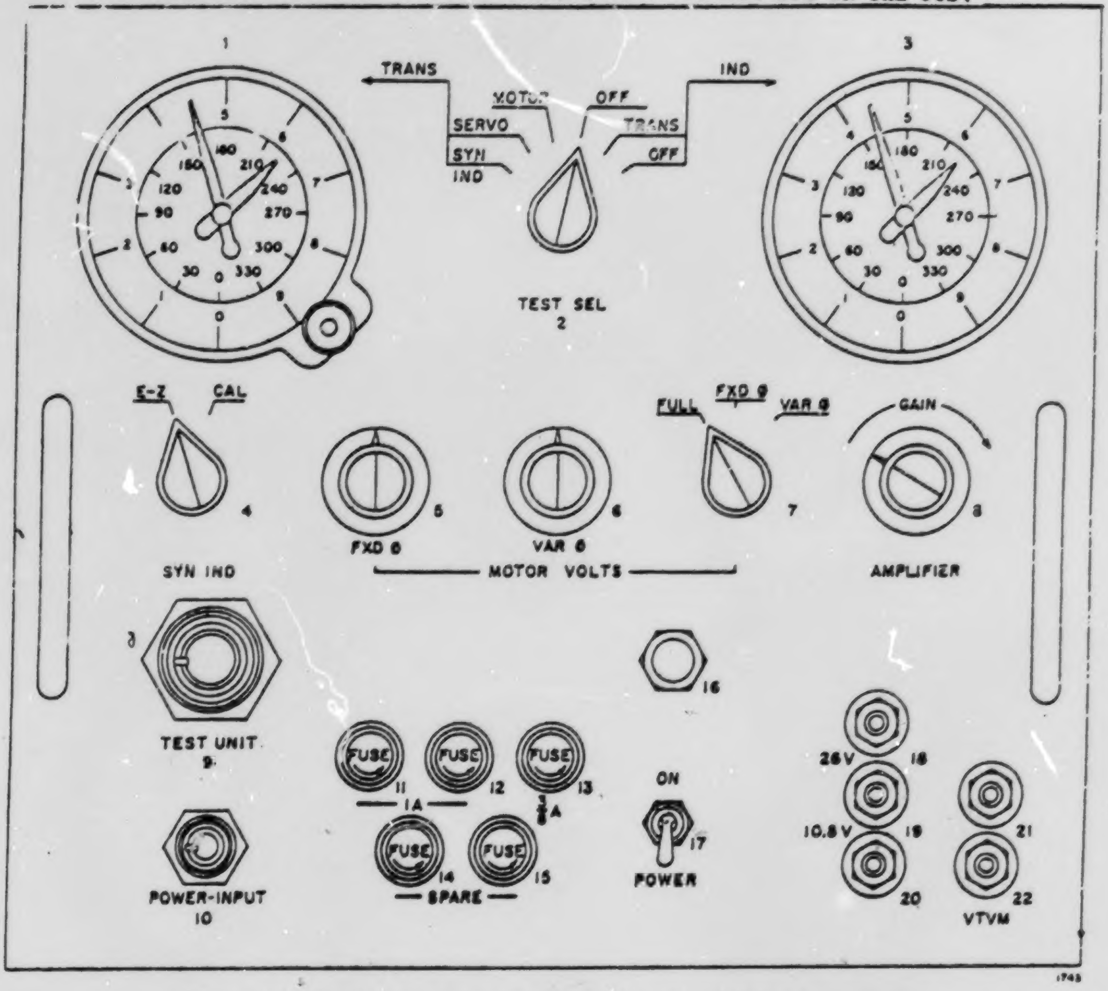
1
TRANS
MOTOR
OFF
IND
SERVO
TRANS
SYN
IND
OFF
3
TEST SEL
2
E-Z
CAL
4
SYN IND
FXD Φ
5
VAR Φ
6
MOTOR VOLTS
FULL
FXD Φ
VAR Φ
7
GAIN
8
AMPLIFIER
TEST UNIT
9
16
FUSE
11
FUSE
12
FUSE
13
1A
3/8 A
ON
POWER
17
FUSE
14
FUSE
15
SPARE
POWER-INPUT
10
26V
18
10.8V
19
20
21
22
VTVM
1745

Figure 4-2. Synchro Instrument Field Test Set, Type 13819-2A, Front Panel

cable QB86062-1 to connect to a 115-volt, 400 cps power supply, and disregard power source cables QB86031-1, QB86032-1, and QB86033-1.

4-7. ELECTRICAL ZERO CHECK.

a. Set the TEST SEL switch to SYN IND and the SYN IND 4 switch to E-Z.

b. The indicator under test will assume its electrical zero position. Check the value against the calibration value for the unit under test.

4-8. ANGLE CHECK.

a. Set the SYN IND 4 switch to CAL, and rotate the test set transmitter "1" to the angles specified for the unit under test, using the calibration booklet for the proper angle settings.

b. The indicator under test should follow the Test Set transmitter within the applicable tolerances specified in the technical manual for the indicator under test.

c. Turn POWER 17 switch to OFF (down) position.

d. Remove connections from unit under test.

4-9. SERVOED INDICATOR ANGLE CHECK.

a. Disconnect the cable from the servoed indicator under test in the aircraft.

b. Connect servoed indicator test cable QB84967-1 between test adapter cable QB86030-1 and the servoed indicator under test.

c. Set TEST SEL 2 switch to SERVO.

d. Connect power source cable QB86033-1 to the disconnected aircraft cable.

e. Set the POWER 17 switch to ON.

f. Check power supply voltages at 26V 18 and 19 binding posts for 26 ±10 percent volts and at 10.8V 19 and 20 binding posts for 10.8 ±10 percent volts.

g. Turn AMPL GAIN 8 control fully clockwise. Allow the SERVO amplifier to warm up for at least one minute

Note

> The signal input voltage to the amplifier can be monitored by connecting a vtvm across the VTVM 21 and 22 binding posts.

h. Rotate the Test Set transmitter 1 to the angles specified in the calibration booklet for the servoed indicator under test.

i. The servoed indicator should follow the test set transmitter settings within the applicable tolerance specified for the indicator under test.

4-10. LOW INERTIA MOTOR DIRECTION TEST.

a. Set TEST SEL 2 switch to MOTOR.

b. Set MOTOR VOLTS 7 switch to FULL to apply 26 volts to the motor windings. The pointers of the servoed indicator under test should move in a clockwise direction.

4-11. LOW INERTIA MOTOR FIXED PHASE STARTING VOLTAGE TEST.

a. Set MOTOR VOLTS 7 switch to FXD Φ.

b. Set MOTOR VOLTS VAR Φ 6 control fully clockwise.

c. Slowly rotate FXD Φ MOTOR VOLTS control 5 clockwise until the pointers of the indicator under test begin to move. Monitor the fixed-phase starting voltage at VTVM 21, 22, binding posts and compare the value with the specification value.

4-12. LOW INERTIA MOTOR VARIABLE PHASE STARTING VOLTAGE TEST.

a. Set MOTOR VOLTS VAR Φ 6 control and MOTOR VOLTS FXD Φ 5 control fully counterclockwise.

b. Set MOTOR VOLTS 7 switch to VAR Φ.

c. Set MOTOR VOLTS FXD Φ 5 control fully clockwise.

d. Slowly move MOTOR VOLTS 6 control clockwise until the pointer of the indicator under test begins to move. Monitor the variable phase starting voltage across the VTVM 21, 22 binding posts. Compare the value with the specification requirement. In no case should the starting voltage (fixed or variable phase) exceed 200 millivolts.

e. Set POWER 17 switch to off (down) position.

4-13. TRANSMITTER TEST PROCEDURE.

a. Disconnect the cable from the transmitter or differential under test in the aircraft.

b. Connect power source cable QB86032-1 to the disconnected aircraft cable and to the POWER-INPUT 10 connector through adapter cable QB86063-1.

c. Connect Autosyn synchro test cable QB84998-1 between test adapter cable QB86030-1 and the unit under test.

d. Set the TEST SEL 2 switch to TRANS.

e. Set the POWER 17 switch to ON.

f. Check power supply voltages as described in paragraph 4-9, step f.

g. Turn the AMPL GAIN 8 control fully clockwise. Allow the servo amplifier to warm up for at least one minute before proceeding.

h. Rotate the unit under test to the angles specified for that unit in the test specifications and see that the Test Set indicator shows the required values.

i. On completion of tests, set all switches to their OFF or fully counterclockwise positions and remove connections from unit tested.

4-14. DIFFERENTIAL TEST PROCEDURE.

When the Test Set is used to test differential Autosyns synchros, use the procedure described in paragraph 4-13, for transmitters, but set the TEST SEL 2 switch to DIFF.

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3-3. INDIVIDUAL TEST.

3-4. ELECTRICAL BREAKDOWN TEST. Apply 550 volts at a commercial frequency between any pin of the electrical connector receptacle and ground (casting) for a minimum of five seconds. There should be no insulation breakdown. If the instrument does not pass this test, inspect for defective parts and replace them. Type 25100 and 25200 indicators shall be tested for electrical breakdown with an applied voltage of 200 volts at a commercial frequency.

CAUTION

> Do not perform this electrical breakdown test in the same room where inflammable fluids are being used.

3-5. ELECTRICAL DAMPING AND ELECTRICAL ZERO TEST. For the purpose of this test only, the indicator being tested must be connected to a single indicator with the glass removed. Do not use the Autosyn precision transmitter for this test. The power source must be disconnected, and the pointer of the single indicator displaced 180 degrees from the pointer position of the indicator being tested. The pointer of the single indicator must be held in position while the power is connected. The cycle must be repeated a minimum of three times. Impose electrical zero on both Autosyns. The tip of the pointers should be within 0.01 inch of each other and within 0.01 inch of the index mark or top center graduation on the dial. If the indicator fails this test, check the electrical zero of both Autosyns and be certain that both pointers are firmly secured to their shafts.

3-6. SCALE ERROR TEST. Rotate the rotor of the Autosyn precision transmitter, Eclipse-Pioneer type 13695-1-A (figure 2-15), so as to bring its pointer to the desired indication. Two readings must be taken: the first before and the second after the instrument is tapped. The difference between the first and second readings must not exceed the friction tolerance of 1-1/2 degrees. The second reading must not exceed the scale error tolerance of 3/4 degrees. If the indicator fails this test, check for pointer drag. If friction is still present, check the ball bearings and brush tension. Replace the Autosyn if friction is still present.

3-7. POSITION ERROR TEST. Set the Autosyn precision transmitter at mid-scale and lock the unit. Take a reading with the indicator in a normal horizontal position. This reading should not differ from the readings with the indicator in any other position by more than the tolerance of 1/2 degree.

3-8. CALIBRATION PROCEDURE. With the indicator connected to the Autosyn precision transmitter, the instrument may be calibrated as follows:

a. Rotate the knob of the Autosyn precision transmitter to the minimum range point of the indicator being tested. See the tables at the end of [illegible] section for the applicable dial.

b. The indicator pointer, being tested, should move to the above minimum range point.

c. Continue this check for all the test points in the applicable table. The tolerance for this calibration check is the same as the tolerance for the Scale Error Test. (See paragraph 3-6.)

d. If the Autosyn indicator cannot be brought to within the required tolerance, determine whether or not the error is of an electrical nature. If so, remove the Autosyn and check it according to the overhaul procedure.

TABLE 3-1

FUEL FLOW		
RANGE:	300-3000 LB/HR 50-500 GAL/HR	
DIAL:	A62-B7A	
LB/HR X 100	CLOCKWISE DEGREES FROM BOTTOM CENTER LINE	
	(Degrees)	(Min)
3	39	
5	59	30
10	112	15
15	165	30
EZ	180	0
20	217	30
25	265	15
30	319	30
GAL/HR	CLOCKWISE DEGREES FROM BOTTOM CENTER LINE	
	(Degrees)	(Min)
50	38	45
100	69	15
150	100	45
200	133	0
250	164	30
300	196	0
350	225	0
400	254	15
450	281	15
500	316	0

TABLE 3-2

FUEL FLOW	
RANGE:	100-1000
DIAL:	A64-B5B
LBS/HR	TEST TRANS. READING CLOCKWISE FROM 6 O'CLOCK
100	44 0'
150	59 53'
200	75 45'
250	91 22'
300	107 0'
350	122 45'
400	138 30'
450	153 30'
500	168 30'
EZ	180 0'
550	184 7'
600	199 45'
650	214 45'
700	229 45'
750	244 52'
800	260 0'
850	274 0'
900	288 0'
950	303 0'
1000	318 0'

TABLE 3-15

PRESSURE

RANGE: 0-10 PSI

DIAL: A64-C3A, -C3B

PSI	TEST TRANS. READING
0	7° 30'
2	40° 30'
4	73° 30'
6	106° 30'
8	139° 30'
10	172° 30'
EZ	180° 0'

TABLE 3-16

PRESSURE

RANGE: 0-20 PSI

DIAL: A64-C4A, -C4B

PSI	TEST TRANS. READING CLOCKWISE DEGREES FROM 6 O'CLOCK
0	7° 30'
4	40° 30'
8	73° 30'
12	106° 30'
16	139° 30'
20	172° 30'
EZ	180° 0'

TABLE 3-17

OIL PRESSURE

RANGE: 0-200 PSI

DIALS: A251-A2A, -A2B, -A2C

PSI	TEST TRANS. READING
0	20°
50	100°
100 (EZ)	180°
150	260°
200	340°

TABLE 3-18

MANIFOLD PRESSURE

RANGE: 10-75 IN. HG

DIAL: A251-A9A

IN. HG	TEST TRANS. READING
10	7° 30'
20	60° 30'
30	113° 30'

TABLE 3-18 (cont)

IN. HG	TEST TRANS. READING
40	166° 30'
EZ	180° 0'
50	219° 45'
60	272° 45'
70	325° 45'
75	352° 30'

TABLE 3-19

FUEL PRESSURE

RANGE: 0-1000 PSI

DIAL: A251-A27A

PSI X 100	TEST TRANS. READING
0	20°
2	84°
4	148°
5 (EZ)	180°
6	212°
8	276°
10	340°

TABLE 3-19A

FUEL PRESSURE

RANGE: 0-1000 PSI

DIAL: A251-A27B

PSI X 100	TEST TRANS. READING
0	22° 30'
1	54° 0'
2	85° 30'
3	117° 0'
4	148° 30'
5 (EZ)	180° 0'
6	211° 30'
7	243° 0'
8	274° 30'
9	306° 0'
10	337° 30'

TABLE 3-20

OIL PRESSURE

RANGE: 0-100 PSI

DIALS: A251-A30A, -A30B, -A30C, -A30D, -A30E

PSI	TEST TRANS. READING
0	20°
20	84°
40	148°
50 (EZ)	180°
60	212°
80	276°
100	340°

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SECTION III

TEST PROCEDURE

3-1. GENERAL.

3-2. Whenever the pressure and temperature during testing are not specified, it should be understood that the tests are to be made at atmospheric pressure, approximately 29.92 inches of mercury, and at room temperature, approximately 25°C (77°F).

NOTE

> Overhaul personnel, working with test equipment having dials calibrated in degrees instead of pounds, will find the Degree Equivalent Conversion Chart, figure 3-5, useful.

3-3. SYNCHRO TRANSMITTER ASSEMBLY.

3-4. FRICTION TEST. Check the rotor shaft of the unit for friction. The maximum allowable friction is 2.7 gram-mm.

3-5. INSULATION BREAKDOWN. Connect a 200-volt supply at commercial frequency between each electrical terminal and the frame. There should be no insulation breakdown when the voltage is raised at a rate not exceeding 75 volts per second from zero to 200 volts, held at that reading for 30 seconds, and returned to zero at the same rate.

3-6. RESISTANCE. Check the resistance of each winding of the stator. It should measure approximately 8 ohms between any two stator lead wires.

NOTE

> The resistance value given above is for reference only and should not constitute a basis for rejection. Polyphase stators should have matched phase resistances but, in general, improperly matched phase resistances will result in output voltage inaccuracies.

Check that the resistance of the rotor is approximately 16 ohms.

3-7. BRUSH CONTACT. Connect a Wheatstone bridge across the rotor leads. Driving the shaft at variable speeds up to 300 rpm, check the resistance. The variation between readings should not exceed two ohms. After this test, assemble the cover to the unit as outlined in paragraphs 3-20, v through x, and repeat above tests (paragraphs 3-3 to 3-7).

3-8. INPUT CURRENT. Using a vacuum tube voltmeter, a 100 ±0.1 ohm precision wire-wound, non-inductive resistor, and a 400-cycle power source with a means of voltage control such as a Variac or similar unit, electrically connect the units as shown in figure 3-1. Adjust the input power source until the voltage across the rotor is exactly 26 volts. Check the current in the rotor winding by measuring the voltage drop across the 100-ohm series resistor. The voltmeter reading should be 20.5 volts, which denotes a 0.205-amp current in the rotor winding.

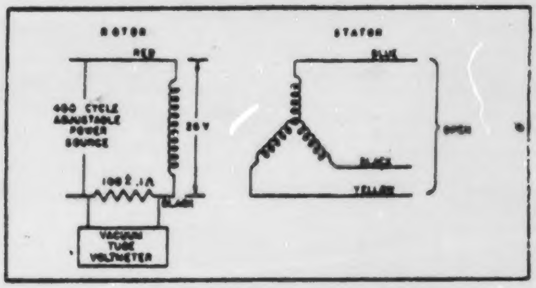

Figure 3-1. Wiring Diagram, Synchro Transmitter Test Set-Up

3-9. ELECTRICAL ZERO. Mount the synchro transmitter horizontally in a suitable holding fixture with a dial plate calibrated from 0 to 360 degrees counterclockwise. Electrically zero the unit by means of an electrical zeroing transformer. Wiring connections for this operation are shown in figure 3-2. Attach a pointer to the shaft, making certain that the pointer is exactly on the zero indication.

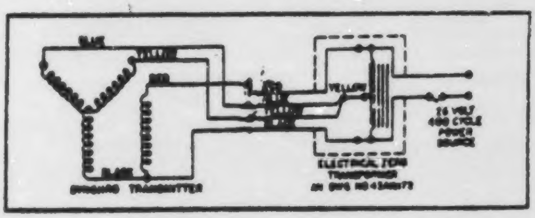

Figure 3-2. Wiring Diagram, Electrical Zeroing Set-Up

3-10. OUTPUT VOLTAGE. With the unit mounted in the fixture, and a voltage of 26 volts across the rotor, check the open circuit output voltages. The maximum open-circuit voltage measured between any two secondary leads shall be 11.8 ±0.3V. The variation between the three maximum secondary voltages on any one synchro shall not exceed 0.2V.

3-11. NULL VOLTAGE. With the unit set up as outlined in paragraph 3-10, the null voltages measured across the open circuit stator leads shall be determined at the angles listed in figure 3-3. The values measured should not exceed the maximum null voltages indicated. This test should be performed using a vacuum tube voltmeter.

Output Connections	Pointer Angle (Counterclockwise)	Maximum Null Volts
Blue-Black	120-300	0.035
Black-Yellow	60-240	0.035
Blue-Yellow	0-180	0.035

Figure 3-3. Null Voltages

OIL PRESSURE TRANSMITTER TYPE MS28005-3

THE INSTRUCTIONS CONTAINED IN PRECEDING SECTIONS OF THIS TECHNICAL MANUAL APPLY EXCEPT FOR THE DIFFERENCES LISTED IN THIS DATA SHEET.

Part Number	ST-411
Range	0 to 200 psi
Degree of Arc	320 degrees
Operating Voltage	26-volt, 400-cycles, single phase
Electrical Connector	MS33678-14S-2P
Mating Plug	MS33678-14S-2S
Electrical Zero	100 psi
Operating Ambient Temperature Range	-65° F to + 160° F
Weight	1.28 lbs

Figure 4-13. Table of Leading Particulars

SPECIAL TOOLS. No special tools required.

TEST EQUIPMENT. Same as Transmitter F-2A (MS28005-2).

DISASSEMBLY. Same as Transmitter F-2A (MS28005-2), except disassemble the arbor assembly as follows (see figure 4-9):

a. Remove the taper pin (2) securing the end of the arbor to the bourdon tube. Remove taper pin (3) and extract link (4). Remove the adjustment screw (7) by unscrewing the locking screw (5) and two hex nuts (6) from the segment (8).

CLEANING. Same as Transmitter F-2A (MS28005-2).

INSPECTION. Same as Transmitter F-2A (MS28005-2).

TESTING (during overhaul). Same as Transmitter F-2A (MS28005-2).

REPAIR OR REPLACEMENT. Same as Transmitter F-2A (MS28005-2).

REASSEMBLY. Same as Transmitter F-2A (MS28005-2), except assemble the arbor as follows (see figure 4-9):

a. Replace the adjustment screw (7) in the segment (8) and fasten with the locking screw (5) and two hex nuts (6) Attach the link (4) with a taper pin (3). Attach the arbor assembly to the bourdon tube with a taper pin (2).

TEST PROCEDURE (after overhaul). Same as Transmitter F-2A (MS28005-2), except for the following:

a. SCALE ERROR TEST. The tolerance must be within the limits given in figure 4-14. This test may be combined with the scale error test.

b. FRICTION TEST. Test the transmitter for friction at the pressure listed in figure 4-14, by reading it before and after tapping it lightly. The readings taken before and after tapping shall not differ by more than ±3.0 psi, ±4.8° arc. This test can be made in conjunction with the scale error test.

NOTE

Overhaul personnel working with equipment having dials calibrated in degrees instead of pounds will find the equivalent readings listed in Figure 4-14.

Pressure		Tolerance	
(psi)	(° arc)	(±psi)	(±° arc)
0	20	3.0	4.8
50	100	3.0	4.8
100 (EZ)	180	4.0	6.4
150	260	4.0	6.4
200	340	4.0	6.4

Figure 4-14. Scale Errors and Degree Equivalents

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PROGRAMMED TEXT

3ABR32531-PT-203

Technical Training

Avionics Instrument Systems Specialist

TACHOMETER SYSTEMS

16 March 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.
Do Not Use on the Job.

Flight Tng Devices/Instrument Branch
Chanute Air Force Base, Illinois

3ABR32531-PT-203

OBJECTIVES

Without reference, identify facts pertaining to the operation of tachometer systems.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading the information in each frame, you are asked to actively respond to the statements at the end of that frame. Check your responses for accuracy with the correct answers that are given after the following frame. If you make an incorrect response, reread the frame until you determine why you were in error before proceeding to the next frame.

Supersedes 3ABR32531-PT-203, 3ABR32632B-PT-303, 19 May 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 300; TTVSA - 1

Frame 1

It was recognized during the early stages of aircraft development that the engine revolutions per minute (rpm) should be known by the pilot at all times. The tachometer system was developed to indicate this very important information. The tachometer dial is a counting device that is graduated to indicate the engine speed in revolutions per minute (rpm) for reciprocating engines and in percent of rpm for jet and turboprop engines. See figure 1 for the indicator for reciprocating engines and figure 2 for the indicator used for jet engines.

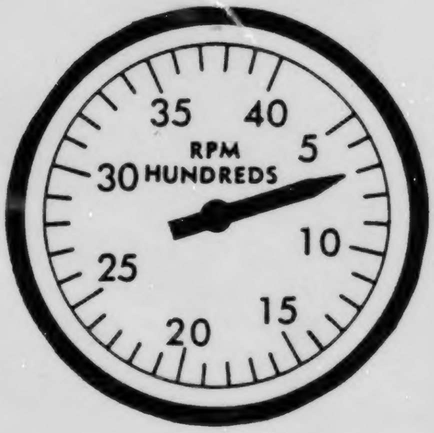


Figure 1.

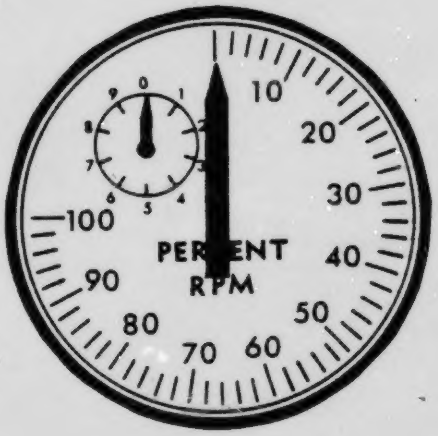


Figure 2.

Refer to the indicators above and circle the letters of the correct responses to the following statements.

1. The tachometer indicator shown on the left is graduated in rpm from

   a. 5 to 40 rpm.
   b. 50 to 400 rpm.
   c. 500 to 4,000 rpm.
   d. 5,000 to 40,000 rpm.

2. The tachometer indicator shown on the right is graduated in

   a. 0-100 revolutions per minute.
   b. 0-100 percent of revolutions per minute.
   c. 0-100 revolutions per hour.
   d. 0-100 percent of revolutions per hour.

Frame 1 (Cont'd)

3. The tachometer indicator shown on the left is used on

   a. jet aircraft.
   b. reciprocating aircraft.
   c. turboprop aircraft.

4. The tachometer indicator shown on the right is used on

   a. jet aircraft.
   b. reciprocating aircraft.
   c. turboprop aircraft.

Frame 2

The tachometer system contains an engine driven, three phase AC generator mounted on the engine accessory section and a motor driven indicator mounted in the pilot's instrument panel. The illustration below shows where the units are mounted and how they are connected to each other. See figure 3 below.

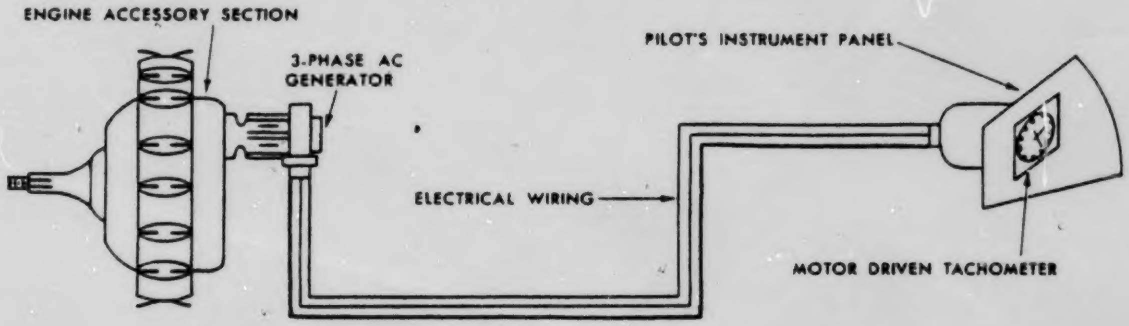

ENGINE ACCESSORY SECTION
3-PHASE AC GENERATOR
PILOT'S INSTRUMENT PANEL
ELECTRICAL WIRING
MOTOR DRIVEN TACHOMETER

Figure 3.

Circle the letter of the correct response to the following statement.

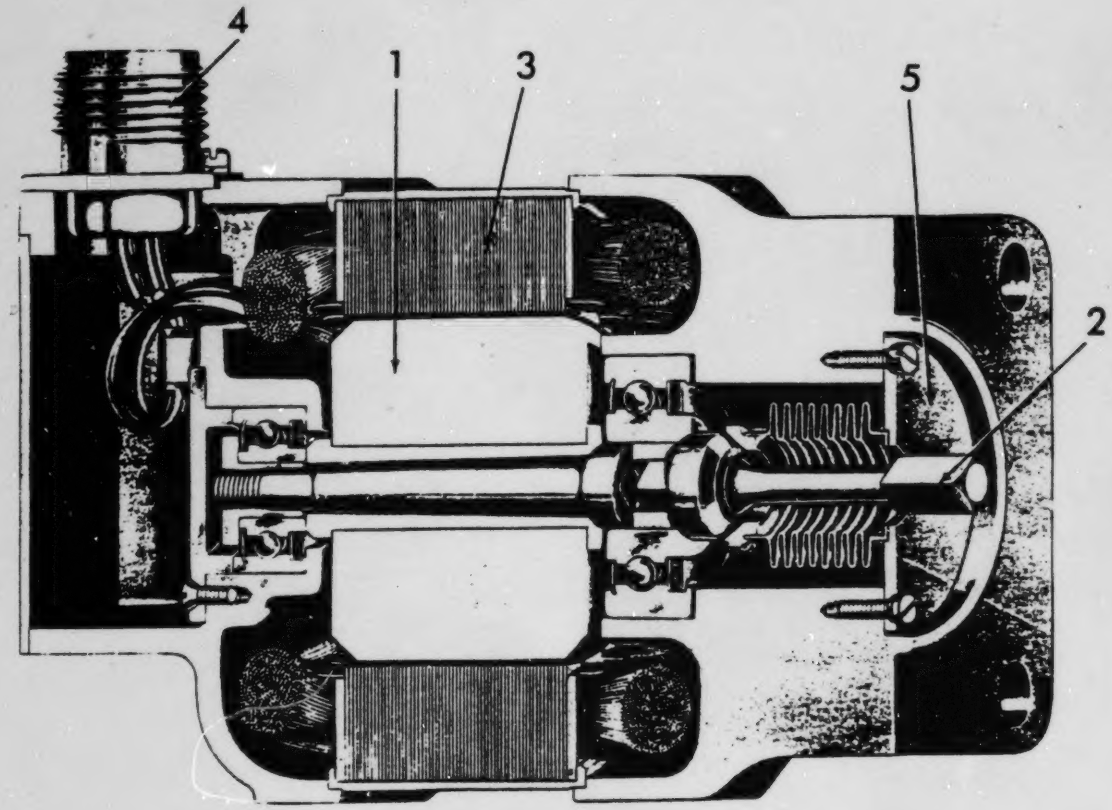
1. The generator is connected to the tachometer indicator by

   a. two electrical wires.
   b. three electrical wires.
   c. two electrical wires and a flexible shaft.
   d. a flexible shaft and a shielded wire.

Answers to Frame 1: 1. c 2. b 3. b 4. a & c

Frame 3

The tachometer generator consists of a two pole or a four pole permanent magnet rotor, drive shaft, three phase wye wound stator, electrical connector, and an oil seal. The illustration in figure 4 below shows a cutaway view of the tachometer generator. The permanent magnet rotor (1) rotates inside the stator (3) as the drive shaft (2) is driven by the engine. The oil seal (5) fits around the drive shaft to keep oil from getting into the rotor and stator housing. The electrical connector (4) is used to connect the generator to the indicator by electrical wiring. See figure 4.



1. Magnet (Rotor)
2. Drive Shaft
3. Stator
4. Electrical Connector Receptacle
5. Oil Seal

Figure 4.

NO RESPONSE REQUIRED

Answer to Frame 2: 1. b

Frame 4

There are two types of tachometer generators used on aircraft engines. They are the two pole and the four pole generators. The two pole type is normally used on jet aircraft engines. The two pole generator has only two pins in the electrical connector because one phase of the signal is internally grounded to the case. The illustration in figure 5a below shows the schematic of the two pole system. The four pole generator is used on reciprocating engines and has three pins in the electrical connector as there is no internal grounding. The illustration in figure 5b below shows the schematic of the four pole system.

TWO POLE SYSTEM

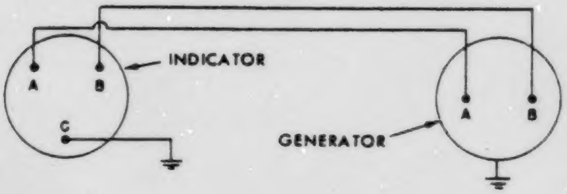


Figure 5a.

FOUR POLE SYSTEM

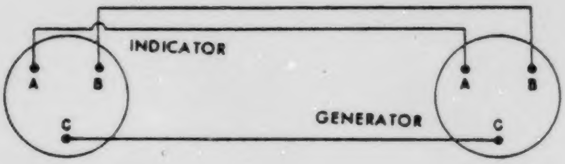


Figure 5b.

Using the above illustrations, circle the letter of the correct response to the following statement.

1. The schematic of the two pole tachometer system contains

   a. two wires only.
   b. three wires only.
   c. two wires and a ground.
   d. three wires and a ground.

Answer to Frame 3: NO RESPONSE REQUIRED

Frame 5

The generator uses either two or four pole rotors. You can see from figure 6 that the rotors are similar in construction and identical in appearance. The only difference between the two pole and the four pole is that they are magnetized differently. Note the arrangement of the poles in figure 6 below.

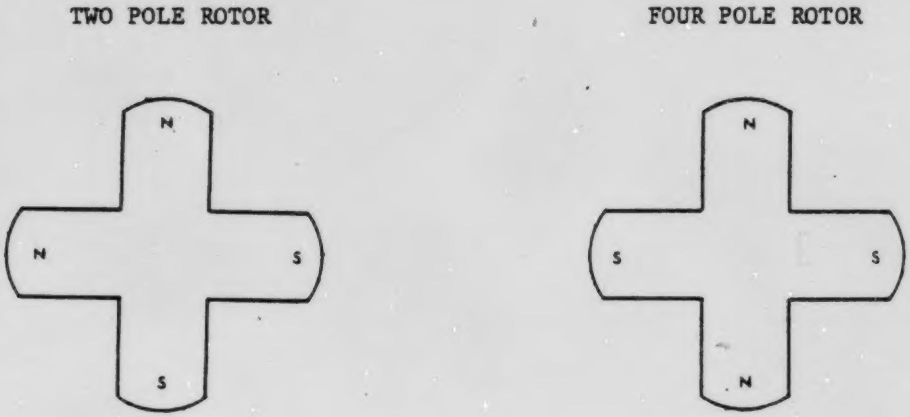


Figure 6.

Using figure 6 above, circle the letter of the correct response to the following statement.

1. The magnet of the two pole generator differs from the four pole generator in that the North poles are

   a. opposite each other in the two pole generator.
   b. next to each other in the four pole generator.
   c. opposite the south poles in the two pole generator.
   d. next to each other in the two pole generator.

Answer to Frame 4: 1. c

690

The two pole magnet rotor is magnetized so that the effective magnetic poles are 180° apart. The four pole magnet rotor is magnetized so that the effective magnetic poles are 90° apart. The drawings in figure 7 below show the two types of rotors. Notice the concentration of the flux lines around the poles of both magnets.

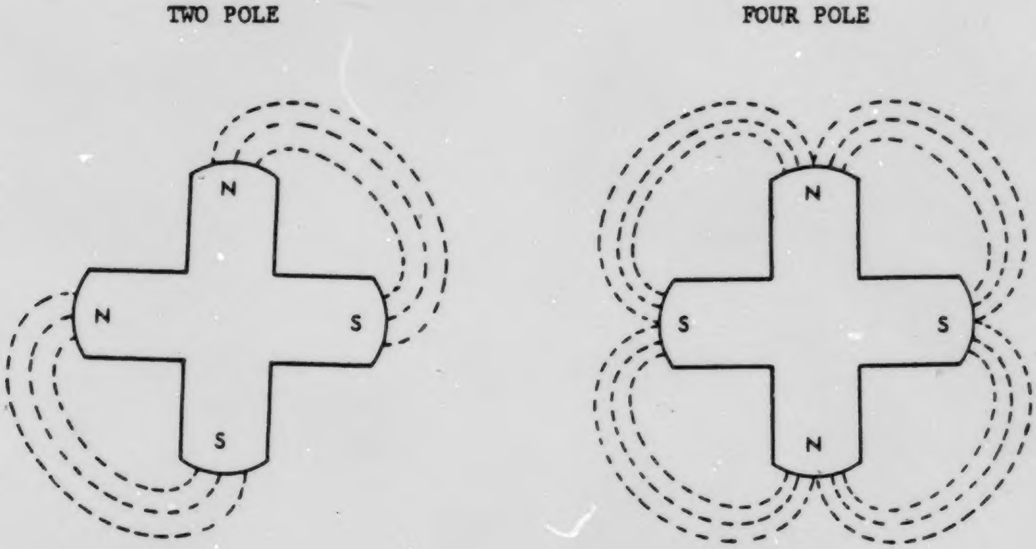


Figure 7.

Circle the letter of the correct response to the following statement.

1. The two pole magnet differs from the four pole magnet in that there are

   a. two effective magnetic fields in the four pole magnet.
   b. four effective magnetic fields in the four pole magnet.
   c. two effective magnetic fields in the two pole magnet.

Answers to Frame 5: 1. c & d

711

Frame 7

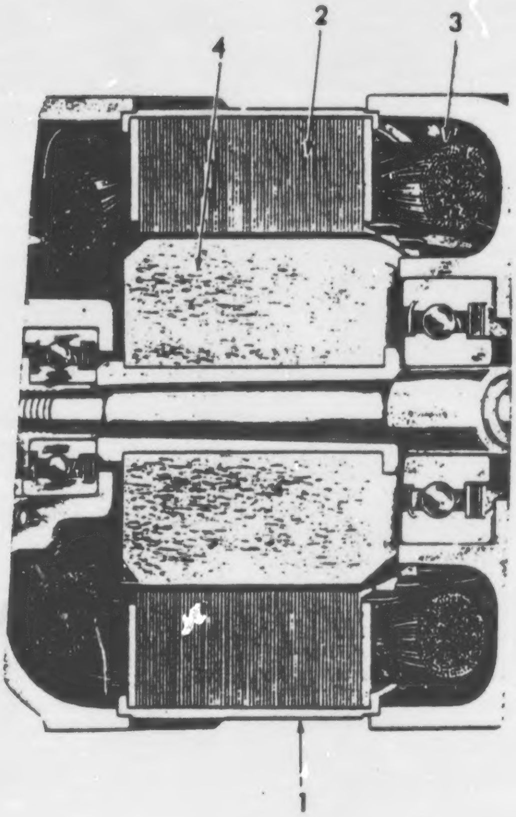
The drive shaft of the generator fits into the tachometer drive of the engine. This drive turns at a speed proportionate to that of the crankshaft.

NO RESPONSE REQUIRED

Answers to Frame 6: 1. b & c

Frame 8

The stator of the generator consists of a steel ring (1) which holds a metal laminated core (2). Around this core is placed a three phase wye connected winding (3). The permanent rotor (4) turns inside the stator and induces a variable three phase AC voltage of variable frequency. See figure 8 below. The voltage and frequency of this generator varies with the speed of the rotor.



1. Steel Ring
2. Laminated Core
3. 3 Phase Wye Windings
4. Rotor

Figure 8

Circle the letter of the correct response to the following statements.

1. Variable voltage is induced into the stator windings by the

   a. rotor turning inside the 3-phase wye-connected stator.
   b. rotor turning inside the 3-phase delta-connected stator.
   c. three-phase wye connected stator turning around the rotor.
   d. rotor turning in one direction and the 3-phase wye-connected stator turning in the other direction.

Frame 8 (Cont'd)

2. The variable frequency output of the generator is determined by the

   a. number of windings.
   b. size of the windings.
   c. strength of the magnetic field.
   d. speed of the rotor.

Answer to Frame 7: NO RESPONSE REQUIRED

Frame 9

The variable voltage and frequency from the generator are connected through electrical wiring to the synchronous motor of the tachometer indicator. The synchronous motor is made up of three parts; a permanent magnet rotor, 3-phase wye wound stator, and a hysteresis disk. The purpose of the permanent magnet rotor is to provide starting and running torque for the motor during low frequency (rpm) when the strength of the rotating field is low. The rotor is mounted loosely on the shaft so that it is free to rotate almost one complete revolution without moving the rotor shaft. At the end of its free rotation, it engages a hairspring through which it transmits a torque to the rotor shaft. This arrangement allows the rotor to synchronize with the rotating field before the shaft picks up any load. See the illustration in figure 9 below.

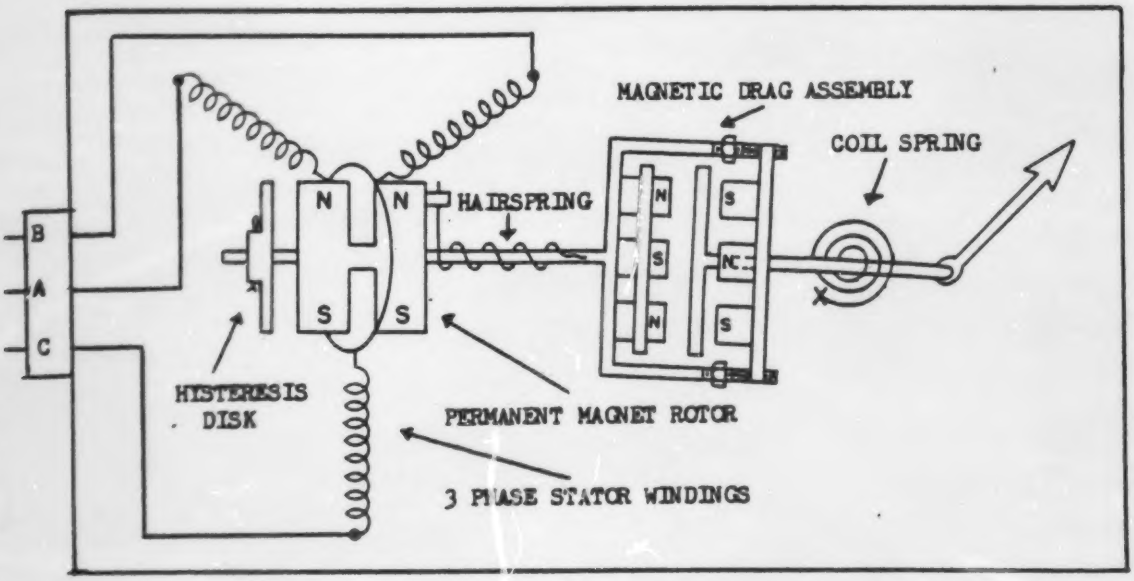

MAGNETIC DRAG ASSEMBLY
COIL SPRING
HAIRSPRING
B
A
C
N
N
S
S
N
S
N
S
N
S
HISTERESIS DISK
PERMANENT MAGNET ROTOR
3 PHASE STATOR WINDINGS

Figure 9.

Circle the letter of the correct response to the following statements.

1. The purpose of the permanent magnet rotor is to provide starting and running torque for motor operation during

   a. high frequencies and low rpm.
   b. low frequencies and high rpm.
   c. high frequencies and high rpm.
   d. low frequencies and low rpm.

695

Frame 9 (Cont'd)

2. The hairspring starts the

   a. permanent magnet rotor to rotate.
   b. hysteresis disk to rotate.
   c. rotor shaft to rotate.

Answers to Frame 8: 1. a 2. d

Frame 10

The purpose of the hysteresis disk is to provide starting (additional) torque when the engine speed is being changed from a fairly high rpm to some other setting. At this time the magnitude of the flux is high but the permanent magnet by itself will not pull the rotor into synchronization. At higher generator speeds, the hysteresis disk moves the rotor up to near synchronization. Then the permanent magnet pulls the rotor into exact synchronization. The hysteresis disk also aids in stabilizing the rotor during quick frequency (rpm) changes and prevents pointer oscillation. See figure 10 below.

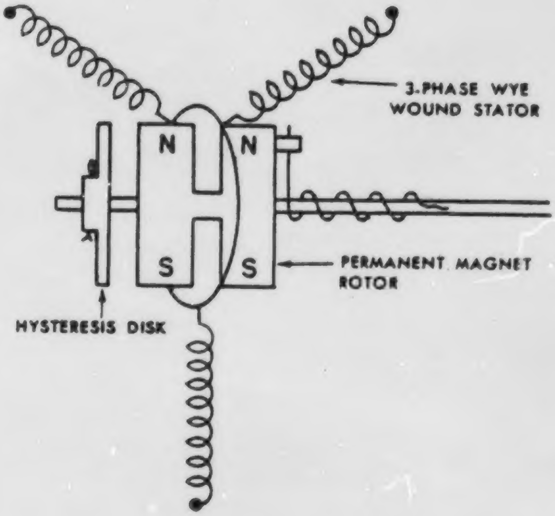


Figure 10.

Using figure 10 above, circle the letter of the correct response to the following statement.

1. The purpose of the hysteresis disk is to provide starting torque at

   a. high frequencies and low rpm.
   b. low frequencies and high rpm.
   c. high frequencies and high rpm.
   d. low frequencies and low rpm.

Answers to Frame 9: 1. d 2. c

Frame 11

The next portion of the tachometer indicator is the magnetic drag assembly which consists of two plates, each with six magnets attached to them. These plates are bolted together so that the small magnets on each plate face each other across an air gap. See figure 11 below. In each case, opposite poles of the magnets face each other. The distance between the plates can be varied by increasing or decreasing the air gap which adjusts for high or low reading.

Note: These adjustments can only be made at DEPOT level maintenance.

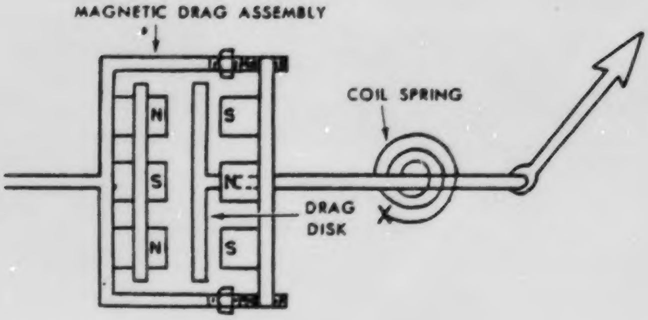


Figure 11.

Circle the letter of the correct response to the following statement.

1. To adjust for a high or low tachometer reading, the

   a. coil spring would be adjusted.
   b. air gap would be adjusted.
   c. hairspring would be adjusted.
   d. speed of the engine would be adjusted.

Answer to Frame 10: 1. c

Frame 12

Placed in the air gap between the magnets is a drag disk made of aluminum. This disk is connected to the pointer shaft either directly or through gears. Eddy currents set up in the drag assembly will attract and turn the drag disk. A coil spring opposes the turning of the disk. If it was not for the coil spring fastened to the pointer shaft (see figure 12 below), the drag disk would spin along with the magnets. However, the spring does oppose the turning of the disk so that the disk will only turn until the opposition of the spring is equal to the torque produced by the magnetic field. This will stop the disk and pointer from turning and indicate the rpm of the engine.

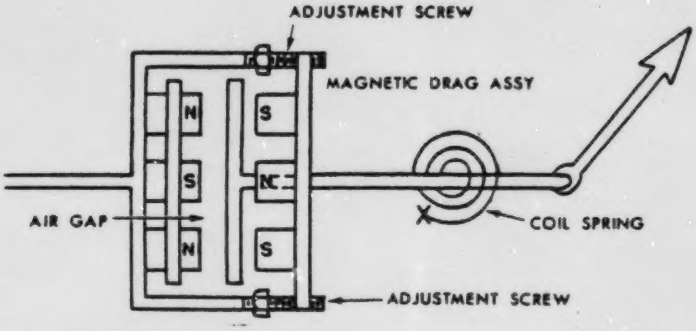


Figure 12.

Circle the letter of the correct response to the following statements.

1. The purpose of the coil spring is to

   a. aid the torque produced by the magnetic field.
   b. oppose the torque produced by the magnetic field.
   c. aid the pointer in turning as rpm changes.
   d. hold the pointer steady when spring tension and torque are unequal.

2. The drag disk in the tachometer indicator is turned by

   a. magnets.
   b. gear train.
   c. eddy currents.
   d. mechanical linkage.

Answer to Frame 11: 1. b

Frame 13

When the rpm of the engine increases, a chain of events takes place. The voltage and frequency of the generator increases, thereby increasing the speed of the synchronous motor of the indicator. This will increase the speed of the magnets in the drag assembly (see figure 13 below) thus causing the drag disk to move until it is balanced by the tension of the coil spring. These same events take place as the speed decreases, but in the opposite direction. Since the rpm of the indicator motor depends more on the frequency of the generator than on the voltage output of the generator, this is called a frequency sensitive system.

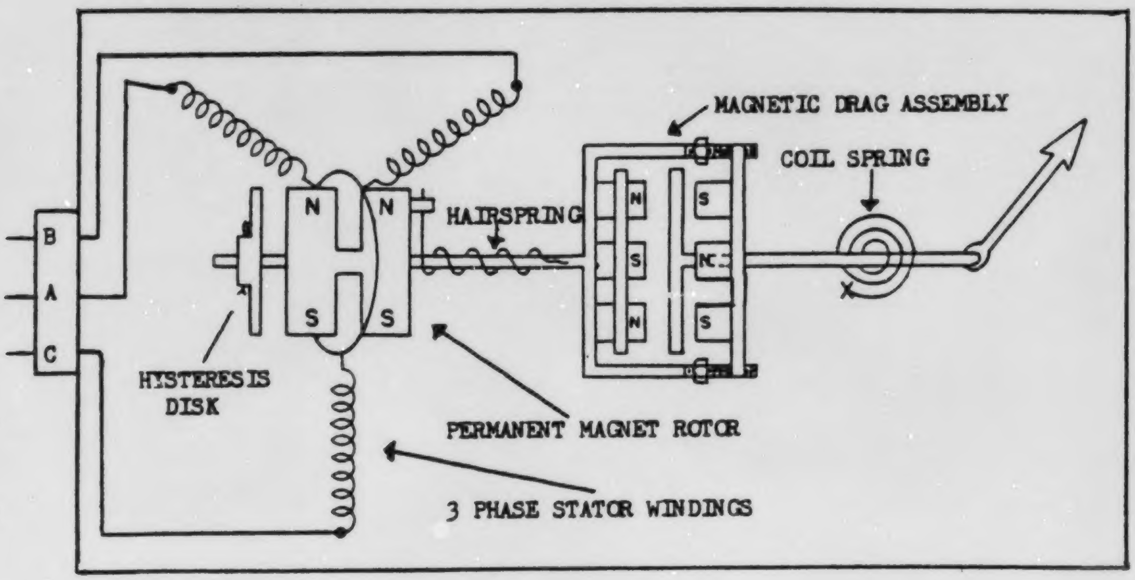

MAGNETIC DRAG ASSEMBLY
COIL SPRING
HAIRSPRING
B
A
C
N
N
S
S
N
S
S
N
N
S
X
HYSTERESIS DISK
PERMANENT MAGNET ROTOR
3 PHASE STATOR WINDINGS

Figure 13.

Circle the letter of the correct response to the following statements.

1. As the speed of the tachometer generator increases, the voltage output

   a. increases and frequency decreases.
   b. decreases and frequency increases.
   c. increases and frequency increases.
   d. decreases and frequency decreases.

2. The synchronous motor speed increases when the generator speed increases due to the frequency

   a. staying the same.
   b. increasing.
   c. decreasing.

Answers to Frame 12: 1. b 2. c

Frame 14

While most jet engines need only one tachometer indicating system, some jet aircraft have two compressor shafts which require monitoring. Since one of the compressors is a low speed and the other is a high speed compressor, two tachometer systems are needed. Whenever two systems are used, the low speed system will be designated the N-1 system and the high speed will be the N-2 system. The N-1 overspeed indicating system shows the pilot when the low speed compressor has exceeded its maximum speed in revolutions per minute (rpm). The N-2 tachometer system will monitor the high speed compressor which we have already discussed. See cutaway of engine below for location of N-1 and N-2 systems.

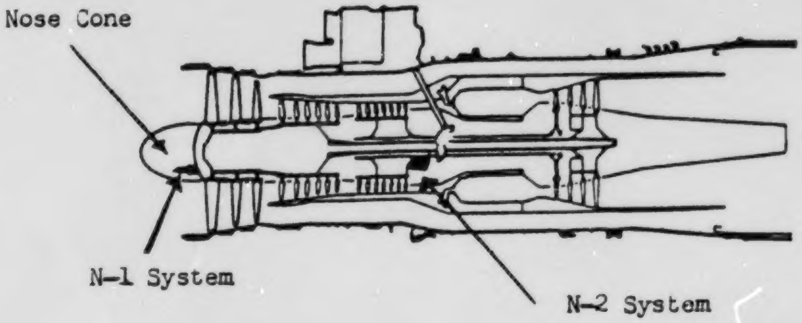


Figure 14.

Circle the letter of the correct response to the following statements.

1. The N-2 tachometer indicating system shows the speed of the

   a. high speed compressor.
   b. low speed compressor.
   c. aircraft propellers.

2. When more than one tachometer indicating system is needed, the low speed compressor tachometer is called the

   a. N-1 system.
   b. N-2 system.
   c. T-1 system.
   d. T-2 system.

Answers to Frame 13: 1. c 2. b

Frame 15

The N-1 overspeed system consists of a tachometer generator identical to the one discussed previously in this text. In addition, the system contains an N-1 overspeed converter and an engine overspeed caution lamp which replaces the indicator for the system. The pilot sees only a go/no go warning of N-1 overspeed trouble. Study figure 15 on the next page to determine the relationship of the N-1 overspeed system components.

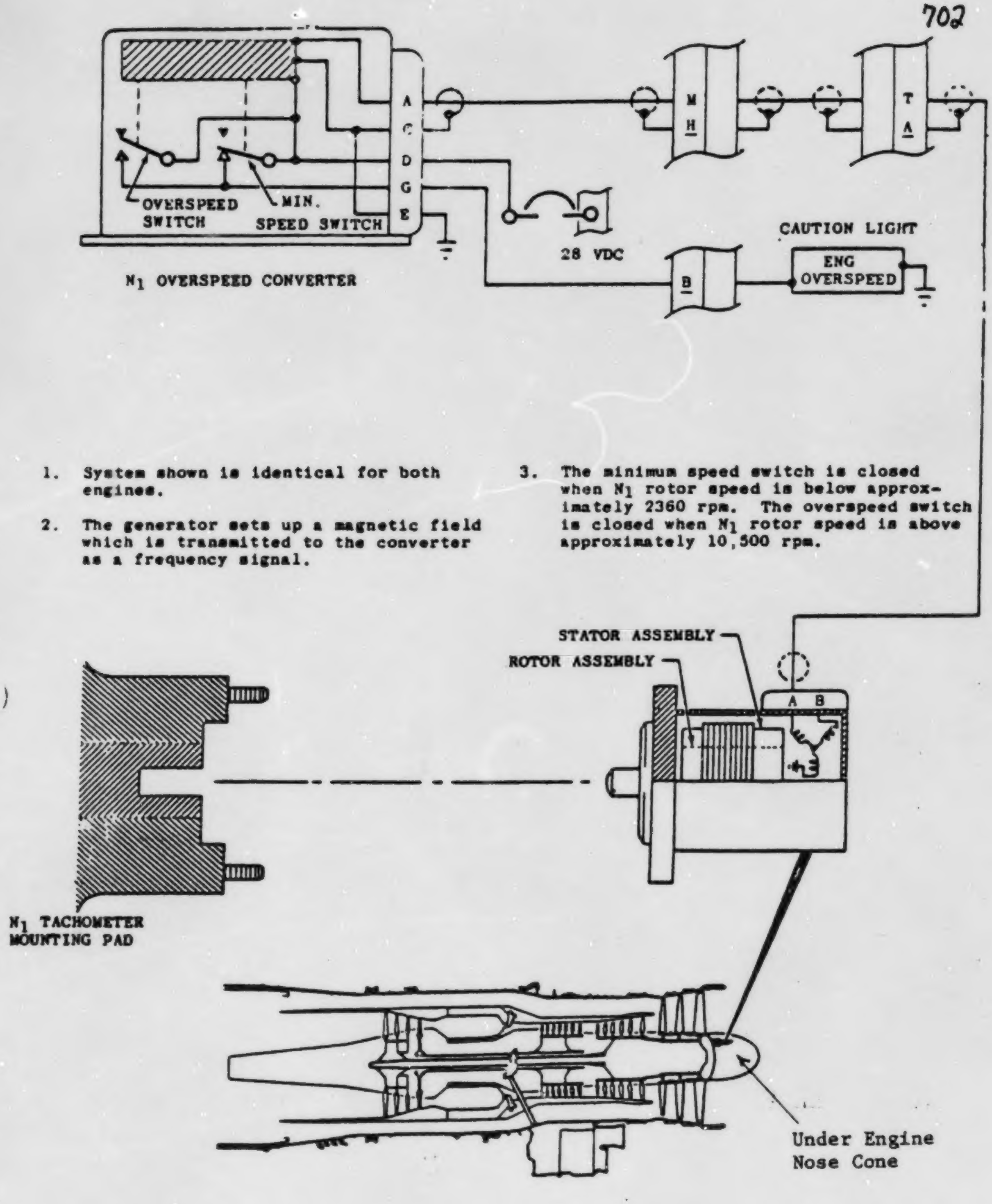
Using figure 15, mark the following statements as True (T) or False (F).

_____1. The N-1 tachometer generator is located under the engine nose cone.

_____2. The N-1 overspeed system needs 28V DC to power the N-1 converter and caution lamp.

_____3. The minimum speed switch is closed at 10,500 rpm.

Answers to Frame 14: 1. a 2. a


A
C
D
G
E
OVERSPEED SWITCH
MIN. SPEED SWITCH
N₁ OVERSPEED CONVERTER
28 VDC
M H
T A
B
CAUTION LIGHT
ENG OVERSPEED
STATOR ASSEMBLY
ROTOR ASSEMBLY
A B
N₁ TACHOMETER MOUNTING PAD
Under Engine Nose Cone

1. System shown is identical for both engines.
2. The generator sets up a magnetic field which is transmitted to the converter as a frequency signal.
3. The minimum speed switch is closed when N_1 rotor speed is below approximately 2360 rpm. The overspeed switch is closed when N_1 rotor speed is above approximately 10,500 rpm.

Figure 15.

703

Frame 16

When the N-1 compressor turns, the generator produces a variable frequency output which is applied to the N-1 overspeed converter. When the frequency in the N-1 compressor exceeds 10,500 rpm, the overspeed switch closes and the engine overspeed lamp illuminates. A minimum speed switch is included in the N-1 overspeed converter. This switch stays closed until the engine gets above 2,360 rpm to self-test the engine overspeed lamp circuit for proper operation.

Circle the letter of the correct response to the following statements.

1. A variable frequency signal is produced by the

   a. tachometer indicator.
   b. engine overspeed converter.
   c. tachometer generator.

2. The function of the minimum speed switch in the N-1 overspeed system is for

   a. operational checking.
   b. self-testing.
   c. dead weight testing.

Answers to Frame 15: T 1. T 2. F 3.

Answers to Frame 16: 1. c 2. b

Now that you have answered the questions in Frame 16, go back to the beginning of the PT and read the objective again. Make sure that you understand the objective.

724

WORKBOOK
3ABR32531-WB-203

Technical Training

Avionics Instrument Systems Specialist

TACHOMETER SYSTEMS

26 April 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-203

TACHOMETER SYSTEMS

OBJECTIVES

Given a workbook, test equipment, and trainer, perform an inspection and operational check of a tachometer system with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainer, troubleshoot a tachometer system with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainer, bench check components of a tachometer system with an accuracy of 100% correct workbook responses.

EQUIPMENT

	Basis of Issue
3ABR32531-WB-203	1/student
Tachometer Indicator (on Engine Instrument Trainer)	1/student
Tachometer Generator (in tester)	1/student
TTU/27E Tester (on lower shelves)	1/student
Multimeter	1/student
3ABR32531-HO-203	1/student

PROCEDURE

Remove all jewelry before inspecting or performing the bench check of the tachometer system components.

TO EXTRACTS are attached to this workbook for use in completing this project. Not all parts of the TOs are used. Read only those parts that you are directed to, by the workbook or the TO itself. Follow the TO procedures carefully so that you do NOT damage the tachometer generator, tachometer indicator, or test equipment.

Note: Obtain all required equipment before starting the lab.

Supersedes 3ABR32531-WB-202, 3ABR32632B-WB-302, 2 September 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 200; TTVSA - 1

Part 1. INSPECTION

1. Visually inspect the tachometer generator for condition and place a check on the proper blank in your response book.

	SAT	UNSAT
a. Cracked or broken case.		
b. Cracked or broken mounting flange.		
c. Bent or broken drive shaft.		
d. Damaged electrical connector.		
e. Bent or broken pins.		

2. Visually inspect the tachometer indicator for:

a. Loose or cracked glass.		
b. Dial and pointers for condition of paint.		
c. Cracked or dented case.		
d. Damaged electrical connector plug.		
e. Bent or broken pins		

Part 2. OPERATIONAL CHECK

1. Refer to section IV, paragraphs 4-1 through 4-4b of the EXTRACT from TO 33D2-6-102-1 for the operating instructions to connect tachometer generator to the TEST SET.

2. Refer to paragraph 8e of EXTRACT TO 5E5-3-3-33 and to paragraphs 4-5 through 4-6f of EXTRACT TO 33D2-6-102-1. Perform the maximum voltage test on the tachometer generator and enter the results in your response book

Phase	Voltage	Satisfactory	Unsatisfactory
A - B			
A - C			
B - C			

3. Refer to paragraph 8e of EXTRACT TO 5E5-3-3-33 and perform the minimum voltage test on the tachometer generator. Enter the results in your response book.

A - B ______ ______ ______

A - C ______ ______ ______

B - C ______ ______ ______

a. Remove test generator and lead from tester.

Part 3. TROUBLESHOOTING THE WIRING HARNESS

1. Place tachometer generator on tester.

2. Using the SPECIAL HARNESS, connect the tachometer generator to the tachometer indicator. (Remove tachometer indicator from engine instrument trainer.)

3. Place the tester power switch to the ON position.

Note: Let tester warm up for approximately one minute.

4. Place switch #11 to master generator position.

5. Place toggle switch on special harness to "ON."

6. Turn power drive knob #9 to increase speed to 2,000 RPM. Check the proper blank in your response book.

a. Tachometer indicator shows an increase in rpm ______, shows a decrease in rpm ______, shows NO change in rpm ______.

b. The tachometer system is satisfactory _____, unsatisfactory _____.

7. Turn power drive knob "9" to OFF position.

8. Place toggle switch on special harness to "OFF."

9. Turn power drive knob "9" to increase speed to 2,000 RPM.

a. Tachometer indicator shows an increase in speed _____, shows a decrease in speed _____, shows NO change in speed _____.

b. Tachometer system is satisfactory _____, unsatisfactory _____.

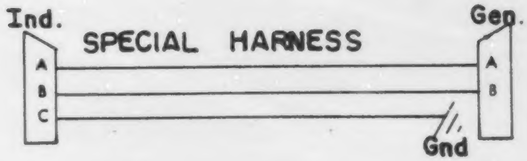
10. Place power drive knob "9" to OFF position.

11. Let tester percent and RPM indicators come to ZERO.

12. Place tester power switch to OFF position.

13. Disconnect special harness from indicator and generator.

14. Use multimeter to find trouble in special harness. Circle the letter of the correct answer.



a. b to b is OPEN.

b. a to a is OPEN.

c. c to c is OPEN.

d. a is SHORTED to b.

Part 4. BENCH CHECK

1. Remove the tachometer generator from the tester and referring to paragraph 8c of EXTRACT TO 5E5-3-3-33, perform a resistance check on the generator. Enter the resistance and check the proper blanks in your response book.

Phase	Ohms	Satisfactory	Unsatisfactory
A - B	______	______	______
A - C	______	______	______
B - C	______	______	______

2. Refer to paragraph 48a, b and c of EXTRACT TO 33D2-6-102-1 and connect tachometer indicator to tester.

a. Refer to paragraph 3-13a (Table V) of EXTRACT TO 5E6-2-20-23 and paragraph 4-8d of EXTRACT TO 33D2-6-102-1. Using the tester as the EQUIVALENT Master Generator, perform the calibration (scale error) check.

b. Hold the indicator in the normal (level) position and tap it lightly for each reading.

c. Record the indicator readings and enter the proper response in the chart in your response book.

SCALE ERROR TEST

Gen. Freq. RPM (CPM)	Ind. Reading Percent RPM	Indicator Reading	Tolerance Percent RPM	SAT	UNSAT
0	0		0.50		
200	4.8		0.50		
400	9.5		0.50		
800	19.1		0.50		
1600	38.1		0.80		
2400	57.1		0.80		
3400	81.0		0.50		
3600	85.7		0.50		
3800	90.5		0.50		
4000	95.2		0.50		
4200	100.0		0.50		

d. Indicator scale error is satisfactory _____, unsatisfactory _____.

3. Referring to paragraph 3-13b and Table VI of EXTRACT TO 5E6-2-20-23, perform the friction error check. Make the proper entries in the chart in your response book.

FRICTION ERROR TEST

Ind. Reading Percent RPM	Allowable Friction Percent RPM	Before Tap	After Tap	SAT	UNSAT
5	1.5				
20	0.8				
40	0.5				
70	0.3				
85	0.3				
100	0.3				

a. The indicator friction error test is satisfactory _____, unsatisfactory _____.

4. Refer to paragraph 13c of EXTRACT TO 5E6-3-20-23. Perform the oscillation check by gradually increasing rpm from 0 to 110% rpm and watching the large pointer. Enter the results in the chart in your response book.

OSCILLATION TEST

Indicator Reading	Oscillation	SAT	UNSAT
Up to 20 percent RPM	0.5 percent RPM		
20 to 110 percent RPM	0.3 percent RPM		

a. The indicator oscillation test is satisfactory _____, unsatisfactory _____.

5. Refer to paragraph 3-14b of EXTRACT TO 5E6-3-20-23 and perform the position error check on the tachometer indicator.

a. Start with the tachometer indicator in the FLIGHT (level) position. Rotate the indicator to the positions specified in the TO to simulate these flight attitudes. Record the results in your response book.

POSITION ERROR TEST

Indicator Reading at 100%	Tolerance	SAT	UNSAT
15° UP	0.30		
15° to the right	0.30		
15° to the left	0.30		
15° DOWN	0.30		

b. The indicator position error test is satisfactory _____, unsatisfactory _____.

6. Perform the starting check on the tachometer indicator as follows: READ paragraph 3-16b of EXTRACT TO 5E6-2-20-23. Calibrate the tester to the required starting voltage by following the procedures in paragraphs 4-9b through d of EXTRACT TO 33D2-6-102-1. Advance the INCREASE SPEED control slowly until the large and small indicator pointers first synchronize (both indicate the same % rpm). Then check the rpm counter on the tester. Make the proper entries in your response book.

a. The speed at which the indicator BEGAN TO OPERATE IS __________ RPM.

b. The starting test is satisfactory ______, unsatisfactory _______.

7. Turn the power drive knob #9 to the OFF position.

8. Allow the counters to return to ZERO.

9. Place the tester power switch to the OFF position.

10. Disconnect tester cables and place in their appropriate place.

11. Place the multimeter to the SAFETY L position (function switch to DC volts, range switch fully clockwise).

12. Remove leads and return ALL equipment to their proper places.

13. Replace indicator back in the panel on engine instrument trainer.

14. Have instructor check your workbook responses for accuracy.

order of disassembly. Refer to the exploded view for relative positioning of components.

b. Assemble the oil seal (28) in the outer recess of the flange end bell assembly (13) so that wiping edge of the seal is facing the drive end of the rotor shaft.

c. Replace the two ball bearings (14) as a complete set (ball cage assembly, inner and outer races). Place the outer race in the end bell bearing recesses with the thin wall facing toward the rotor.

d. Assemble each of the two bearing retainers (24) on the rotor subassembly (16 or 20) so that the curved surface faces the bearing.

e. Press the two inner races on the rotor shaft until fully seated.

NOTE

Before pressing the inner race on the terminal end of the rotor shaft, centrally locate the pin (17 or 21) so that it does not project beyond the drive shaft surface.

f. When rotor assembly (15 or 19), stator assembly (27) and end bell assemblies (12 and 13) are assembled with ball cage assembly in position, the rotor end play should be between 0.0005 and 0.003-inch. In case of excessive or insufficient end play, replace the bearing shim (25) with a thinner or thicker shim as required.

NOTE

Three sizes of bearing shims are available: 0.002, 0.006, and 0.012-inch, respectively.

g. Replace the terminal receptacle (8) so that the receptacle key is toward the drive end. Place new insulation sleeving on the lead wires and resolder to the receptacle pins in the same respective positions as they were disassembled. Slide the insulation over the soldered connections and position the lead wires so that they do not rest against the generator frame.

h. Before completing the reassembly, perform tests 8a, b and c. Upon completion of these tests, assemble the lead clamp (5), gasket (2), and nameplate (1), using screws (3) and (6), and washers (4) and (7) as shown in the exploded view. Then complete performance tests.

8. TEST PROCEDURE.

a. INSULATION BREAKDOWN. Apply a test potential (220 volts a-c, 60 cycles per second for a period of five seconds) between the individual electrical pins and the generator frame, including the shell of the terminal receptacle. There should be no insulation breakdown.

b. CONTINUITY. Test for continuity in all three phases (A-B, A-C, B-C) at the receptacle using a suitable test circuit with indicating lamp connected in series. Failure of the lamp to light indicates an open circuit in the stator. If defective, replace the stator and repeat the test.

c. RESISTANCE. Measure the resistance of each phase (A-B, A-C, B-C) at the receptacle. At 25°C (77°F), the resistance of each phase should be between 20 and 30 ohms. Resistance readings for each of the three phases should be within one ohm of each other. If not within limits, replace stator assembly.

NOTE

After the preceding tests have been made, complete the reassembly of the generator.

d. PHASE ROTATION. Connect the tachometer generator to a suitable phase indicator. Rotate the drive shaft in a counter-clockwise direction as viewed from the drive end. Phase rotation should be B-A-C. The phase rotation may be reversed by interchanging the lead connections of terminals "A" and "B" of the terminal receptacle.

e. TERMINAL VOLTAGE. Connect the tachometer generator to a load of three 40-ohm resistances, wye connected. Drive the generator at 4200 revolutions per minute and measure the three terminal voltages; readings should be between 20.5 and 21.5 volts. Then connect the unit to a load of three 20-ohm resistances (wye connected) and, operating the equipment at a speed of 1000 revolutions per minute, again measure the three terminal voltages which should not be less than 3.5 volts minimum. Replace stator assembly if not within limits.

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TABLE II

CALIBRATION CHECK POINTS
FOR MODEL 8DJ43BAH14

Generator Frequency, CPM	Indicator Reading, RPM	Tolerance, RPM
600	600	±30
1000	1000	±20
1400	1400	±20
1800	1800	±15
2200	2200	±15
2600	2600	±20
3000	3000	±20
3600	3600	±40

b. After calibration has been checked, and with the indicator still connected as in paragraph 3-12a, run the generator at each value given in Tables III and IV as applicable. Note the pointer reading before and after lightly tapping. The difference in readings should not exceed the friction limits shown.

TABLE III

FRICTION CHECK POINTS
FOR MODEL 8DJ43AAF14

Generator Frequency, CPM	Indicator Reading, RPM	Allowable Friction, RPM
1000	1046	±15
1500	1569	±15
2000	2092	±15
2500	2615	±15

TABLE IV

FRICTION CHECK POINTS
FOR MODEL 8DJ43BAH14

Generator Frequency, CPM	Indicator Reading, RPM	Allowable Friction, RPM
1000	1000	±15
1500	1500	±15
2000	2000	±15
2500	2500	±15

c. Oscillation: Pointer oscillation over the scale range shall not exceed the following:

For Model 8DJ43AAF14: 25 RPM
For Model 8DJ43BAH14: 5 RPM

3-13. For Model 8DJ43AAM14.

a. Connect the indicator to a 2-pole generator (MS28054-1 or equivalent) and run the generator to give the output frequencies shown in Table V. Indicator readings should be within the tolerance shown at each successive check point.

TABLE V

CALIBRATION CHECK POINTS
FOR MODEL 8DJ43AAM14

Generator Frequency, CPM	Indicator Reading, Percent RPM	Tolerance, Percent RPM
0	0	0.50
200	4.8	0.50
400	9.5	0.50
800	19.1	0.50
1600	38.1	0.80
2400	57.1	0.80
3200	76.2	0.50
3400	81.0	0.50
3600	85.7	0.50
3800	90.5	0.50
4000	95.2	0.50
4200	100.0	0.50
4400	104.8	0.50

b. After calibration has been checked, and with the indicator still connected as in paragraph 3-13a, run the generator to give each indicator reading shown in Table VI. Note the pointer reading before and after lightly tapping. The difference in reading should not exceed the friction limits shown.

TABLE VI

FRICTION CHECK POINTS
FOR MODEL 8DJ43AAM14

Indicator Reading, Percent RPM	Allowable Friction, Percent RPM
5	1.5
20	0.8
40	0.5
70	0.3
85	0.3
100	0.3

c. Oscillation: Large pointer oscillation shall not exceed the following:

Indicator Reading	Oscillation
Up to 20 Percent RPM	0.5 Percent RPM
20 to 110 Percent RPM	0.3 Percent RPM

3-14. POSITION ERROR TEST.

a. For Models 8DJ43AAF14 and 8DJ43BAH14. The position error at 2000 CPM input should not exceed 15 RPM (5 RPM for Model 8DJ43BAH14) when the indicator is rotated 45 degrees up, 45 degrees to the right, and 45 degrees to the left.

b. For Model 8DJ43AAM14. The position error at 100 percent should not exceed 0.30 percent when the indicator is rotated 15 degrees up, 15 degrees to the right, 15 degrees to the left, and 15 degrees down.

3-15. STARTING TEST.

3-16. Test the indicator for starting characteristics as follows:

a. For Models 8DJ43AAF14 and 8DJ43BAH14. With the generator running at the output frequency shown below, the voltage at which the indicator starts to run at synchronous speed shall not exceed:

Generator Frequency, CPM	Voltage
1000	4.0
2000	8.0

b. For Model 8DJ43AAM14. Connect the indicator to a variable-frequency power supply. The voltage of the supply in volts shall be equal to 0.0035 times the frequency in cycles per minute. Increase the frequency of the supply gradually from zero cycles-per-minute. The generator output frequency at which synchronous indicator operation is reached, shall not exceed 180 CPM.

3-17. For all 8DJ43 Series Models.

a. Test indicator for leaks. (See paragraph 2-32.d.5.)

b. Test for fogging of the window. Place the indicator for two hours in a chamber having a circulating air temperature of 90° ± 5° C (194° ± 10° F.) Within 30 seconds after removing the indicator from the chamber, immerse the indicator face one to two inches in a water bath. The temperature of the water bath should be from 0° to 5° C (32° to 41° F). After five minutes remove the indicator from the bath and dry with compressed air. There should be no evidence of moisture or other deposits on the inner face of the cover glass.

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SECTION IV

OPERATION INSTRUCTIONS

4-1. OPERATING CONTROLS AND INDICATORS.

4-2. The instructions given in this section provide operating procedures for the tachometer tester. Before attempting to operate the equipment, become thoroughly familiar with the controls and indicators illustrated in figure 4-1. The functions of all controls and indicators are given in figure 4-2.

4-3. PRELIMINARY CONNECTIONS AND OPERATION.

NOTE

Reference numbers in parentheses in this and in the operation paragraphs refer to figure 4-1.

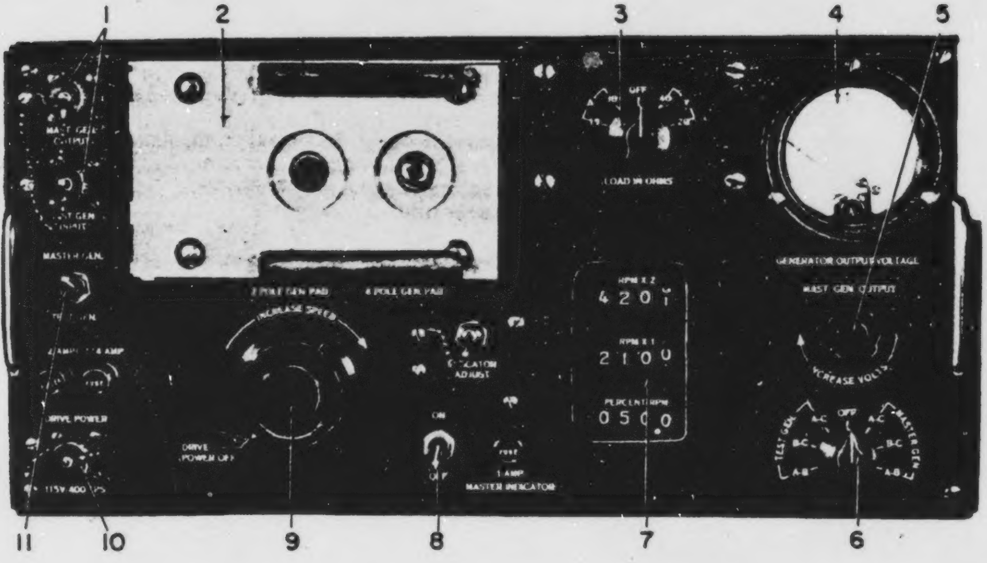
1
2
3
4
5
MAST GEN OUTPUT
TEST GEN INPUT
MASTER GEN.
TEST GEN.
DRIVE POWER
115V 400 CPS
OFF
LOAD IN OHMS
2 POLE GEN PAD
4 POLE GEN PAD
INCREASE SPEED
DRIVE POWER OFF
INDICATOR ADJUST
ON
OFF
FUSE
1 AMP
MASTER INDICATOR
RPM X 2
4 2 0 1
RPM X 1
2 1 0 0
PERCENT RPM
0 5 0 0
GENERATOR OUTPUT VOLTAGE
MAST GEN OUTPUT
INCREASE VOLTS
TEST GEN
MASTER GEN
A-C
B-C
A-B
11
10
9
8
7
6

Figure 4-1. Tachometer Tester, Front Panel

Control or Indicator	Figure 4-1 Index No.	
MASTER GEN. -- TEST GEN.	11	This switch is left in the MASTER GEN. position at all times, except when the tester is used to check a system on an aircraft during runup, in which case, it is changed to the TEST GEN. position.
INCREASE SPEED	9	This control is used to energize the drive motor and to vary the drive speed to both the master tachometer generator and the generator under test. The control is used during tachometer generator and tachometer indicator tests. To increase drive speed, turn the control clockwise. The drive motor is deenergized when the control is turned fully counterclockwise.
MASTER INDICATOR switch	8	When in the ON position, this switch supplies power to the master indicator.

Figure 4-2. Table of Operating Controls and Indicators (Sheet 1 of 2)

715

Control or Indicator	Figure 4-1 Index No.	Function
RPM Indicator	7	This indicator contains three four-digit counters that readout tachometer generator speeds in RPM X 1, RPM X 2, and PERCENT RPM, as measured by the precision speed indicator circuit of the tachometer tester. All three counters indicate simultaneously.
LOAD IN OHMS	3	This five-position switch is used during tachometer generator tests for connecting either a delta- or wye-connected, three-phase load to the tachometer generator under test. Both 15- and 30-ohm loads are provided in three-phase delta connection; 20- and 40-ohm loads are provided in wye connection.
VOLTMETER Selector switch	6	This seven-position switch provides connections for monitoring the voltage across phase A-C, B-C, or A-B of the tachometer generator. When in the TEST GEN. position, it monitors the tachometer generator under test. In the MASTER GEN. position, it monitors the output to the indicator under test. Monitoring of this output is required during adjustment of the MAST. GEN. OUTPUT control. The switch is normally left in the OFF position.
MAST. GEN. OUTPUT	5	This control adjusts the output voltage of the master tachometer. The output voltage is monitored only when the voltmeter switch is in the MASTER GEN. position (i.e., during indicator tests).
GENERATOR OUTPUT VOLTAGE	4	This voltmeter indicates the voltage obtained across phase A-C, B-C, or A-B of the tachometer generator under test, or across the phases of the tachometer indicator under test, depending upon the setting of the voltmeter selector switch.

Figure 4-2. Table of Operating Controls and Indicators (Sheet 2 of 2)

4-4. Perform the following preliminary steps prior to performing any tests:

a. Connect tachometer tester to a source of 115-volt, 400-cycle power, connect the alligator clip to the metal plate on the bench.

CAUTION

Operate the tachometer tester only from a 115-volt, 400-cps, single-phase power source capable of furnishing 250 volt-amperes.

b. Set the MASTER INDICATOR switch (8) to ON. Allow a five-minute warm-up period.

4-5. OPERATIONAL PROCEDURE, GENERATOR TESTS.

4-6. To test tachometer generators, proceed as follows:

a. Install generator to be tested on proper generator test pad (2).

NOTE

The equipment is furnished with two test pads so that optimum use can be made of drive speed resolution. The 4 POLE GEN. PAD rotates at exactly one-half the speed of the 2 POLE GEN. PAD. The pads are arranged so that installation of more than one generator at a time may be prevented, thus preventing accidental overloading of the drive system. A generator is installed by inserting the shaft into the pad socket, and twisting the generator body approximately one-half turn to secure its flange under the spring clips of the pad. It is helpful in the above procedure to allow the drive to rotate slowly (under 100 rpm) while inserting the generator shaft.

b. Connect the appropriate cable between generator and TEST GEN INPUT connector (1).

c. Turn LOAD-IN-OHMS control (3) to the value specified in the T.O. for the generator under test.

d. Set the MASTER GEN.--TEST GEN. control at TEST GEN.

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e. Bring generator speed up to the specified value by turning the INCREASE SPEED control (9) and observing the speed indication on the RPM indicator (7).

NOTE

When testing four-pole generators, the generator shaft speed will be one-half the reading indicated on the RPM indicator. The required shaft speed is obtained when the RPM X 1 scale reads twice the required speed. The extreme counterclockwise position of the INCREASE SPEED control actuates a power switch that deenergizes the drive system. Clockwise rotation of the control increases speed. The INCREASE SPEED control should always be at the extreme counterclockwise position before removing or installing a generator on the test pad, or before connecting or disconnecting power to the tester.

f. Observe voltage output across each phase of the generator under test by turning VOLTMETER Selector switch (6) to each of the three TEST GEN. positions and reading the output voltage on GENERATOR OUTPUT VOLTAGE meter (5).

4-7. OPERATIONAL PROCEDURE, INDICATOR TESTS.

4-8. SPEED CALIBRATION.

a. Connect indicator to be tested by means of appropriate cable to MAST. GEN. OUTPUT connector (1).

CAUTION

If the indicator is bench tested, do not allow the case to be grounded.

b. Set MASTER GEN.--TEST GEN. switch (11) to MASTER GEN. position.

c. Set MAST. GEN. OUTPUT control (5) to its extreme clockwise position.

d. Compare the RPM indicator readings with the readings of the indicator under test at the speeds specified in the T. O. for the indicator.

4-9. STARTING VOLTAGE.

a. Perform steps a and b of paragraph 4-8.

b. Rotate INCREASE SPEED control (9) until a reading of 4000 ±10 rpm is observed on the RPM X 1 scale of the RPM indicator (7).

c. Turn VOLTMETER Selector switch (6) to MASTER GEN. A-C position.

d. Turn MAST. GEN. OUTPUT control (5) until a reading of 14.0 volts is obtained on the GENERATOR OUTPUT VOLTAGE meter (4). The master generator is now calibrated to provide 0.0035XF volts as specified in the indicator T.O. Reduce drive speed to zero and then increase gradually until indicator under test just starts to pull in at a synchronous speed. This speed should be equal to, or less than, that specified for starting voltage in the indicator T. O.

4-10. USE OF TACHOMETER TESTER FOR ENGINE RUN-UP.

4-11. To use tachometer tester for engine run-up, proceed as follows:

a. Connect "T" adaptor into cable harness at aircraft tachometer indicator or generator.

b. Connect appropriate cable assembly to interconnect "T" adaptor and TEST GEN INPUT connector on tachometer tester.

c. RPM indicator now provides an accurate measurement of engine speed.

CAUTION

Do not operate the two-speed test pad when the tachometer tester is used during engine run-up.

4-12. DEENERGIZING AND SECURING THE EQUIPMENT.

4-13. To deenergize the tachometer tester at any time, turn the INCREASE SPEED control to DRIVE POWER OFF (fully counterclockwise) and the MASTER INDICATOR switch to OFF.

4-14. If the tachometer tester is to be secured, disconnect the power and test cables and stow them in the storage compartment of the case assembly. Close and secure the lid.

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PROGRAMMED TEXT
3ABR32531-PT-204
3ABR32632B-PT-304

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

TEMPERATURE INDICATING SYSTEMS

18 July 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

718

FOREWORD

This programmed text was prepared for use in courses 3ABR32531, Avionics Instrument Systems Specialist, and 3ABR32632B, Integrated Avionic Systems Specialist. This text has been validated using 30 students from the subject courses. Twenty-eight of the students achieved the objective as stated. The average completion time is 60 minutes.

OBJECTIVES

Without references, identify facts pertaining to the purpose, operation, and/or characteristics of typical temperature indicating systems

a. resistance thermometer

b. thermocouple thermometer

c. turbine inlet temperature

with an accuracy of at least 80%.

INSTRUCTIONS

This programmed text is divided into three sections; Section A covers the resistance thermometer system, Section B covers the thermocouple thermometer system, and Section C covers the turbine inlet temperature system (3ABR32632B ONLY). The information presented in this text is in small steps called "frames". After reading the information in each frame you are asked to actively respond to the statements at the end of that frame. Place your response on the answer sheet provided with this text. Check the accuracy of your responses with the correct responses given at the end of the following frame. If you make an incorrect response, reread the frame until you determine why your response was in error. After completing each required section you will take an appraisal to display your attainment of the stated objective. Work as quickly as possible, but DO NOT RUSH!

Supersedes 3ABR32531-PT-204, 7 November 1972; 3ABR32531-PT-206, 3ABR32632B-PT-302, 11 December 1974; 3ABR32632B-PT-302A, 29 October 1974.
OPR: 3360TTG
DISTRIBUTION: X
3360TTGTC-W - 200; TTVSR - 1

720

719

SECTION A. RESISTANCE THERMOMETER
(3ABR32531 and 3ABR32632B)

Frame 1

Figure 1 below shows a room type thermometer that is accurate, simple, and has no moving parts. It needs no electrical plugs and measures temperature in degrees Fahrenheit. It is a good, cheap thermometer for the home. However, it does have its drawbacks. You can't read outside temperature when your snuggled up close to the television set. It is a direct reading thermometer. You must go to the thermometer to read it.

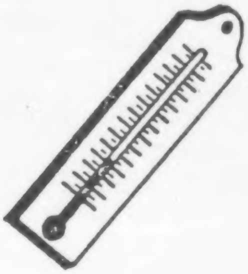


Figure 1.

Circle the letter of the correct response to the following statement(s).

1. The greatest disadvantage of a glass bulb thermometer is its

    a. inaccuracy.

    b. cheap construction.

    c. Fahrenheit scale.

    d. direct reading feature.

740

Frame 2

The resistance thermometer system is used to measure temperatures outside the aircraft. It is accurate, cheap, and simple. The thermometer measures the temperature in degrees Celsius (centigrade) and is a remote indicating system. Therefore, you can remain in the cockpit and check the free air (outside air) temperature. See figure 2. The indicator is placed at a crew station and the temperature bulb in an area in which the temperature is to be measured.

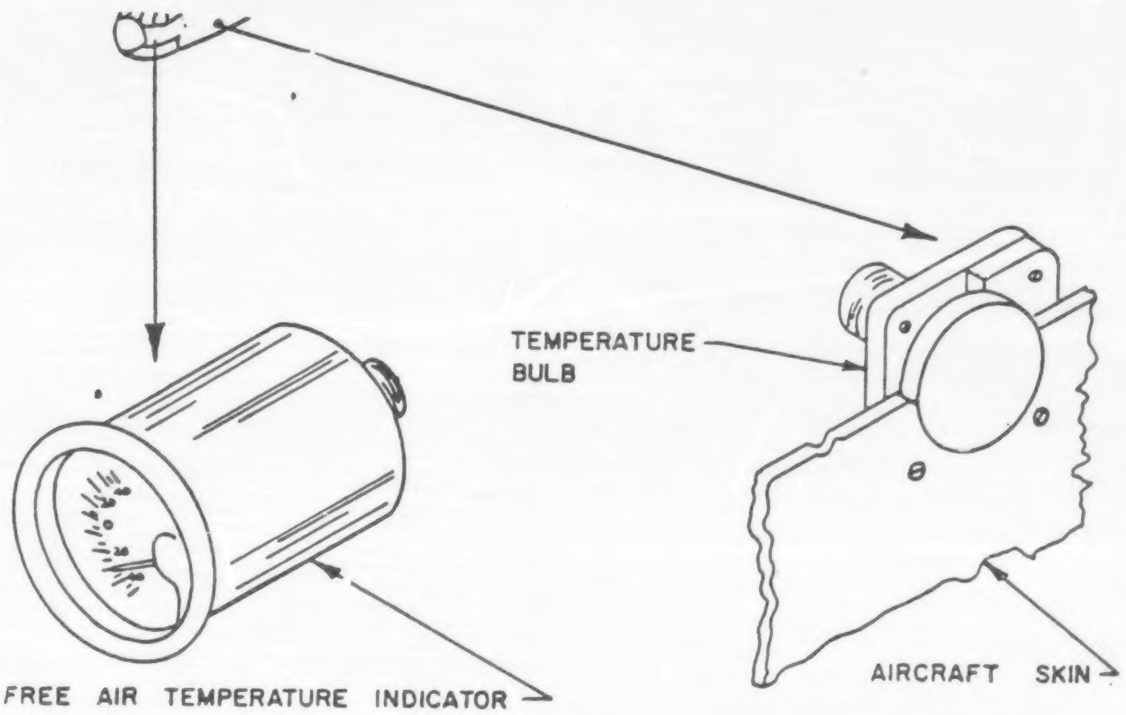


Figure 2.

Circle the letter of the correct response to the following statement(s).

1. The greatest advantage of the resistance thermometer system is its

   a. accur

   b. low cost.

   c. Celsius scale.

   d. remote reading feature.

ANSWER TO FRAME 1: 1. d

The resistance thermometer system operates on 28V DC. The voltage is supplied from the aircraft 28V DC power bus bar and is applied to the indicator receptacle. See figure 3.

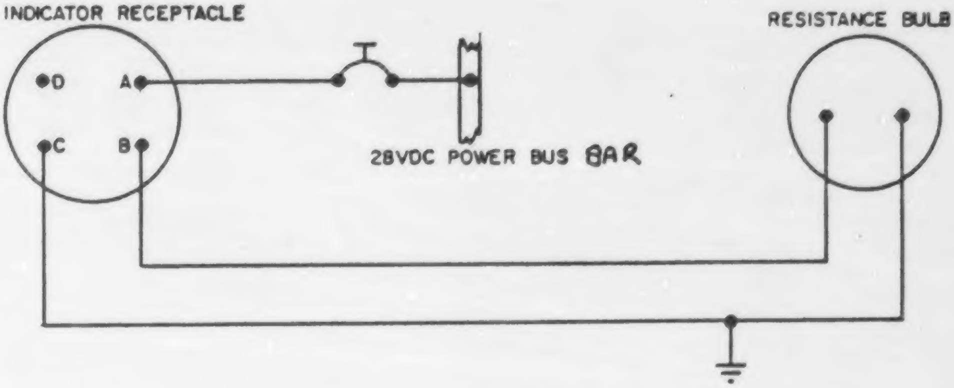

INDICATOR RECEPTACLE
D
A
C
B
28VDC POWER BUS BAR
RESISTANCE BULB

Figure 3.

Circle the letter of the correct response to the following statement(s).

1. The resistance thermometer indicator has 28V DC applied from the

   a. resistance bulb.

   b. aircraft battery.

   c. DC power bus bar.

   d. AC power bus bar.

ANSWER TO FRAME 2: 1. d.

722

Frame 4

Some aircraft require more than one resistance thermometer indicating system in order to provide remote temperature readings for different crew members. Figure 4 shows the copilot's and navigator's resistance thermometer systems. The two systems are not connected electrically, although both use the same 28V DC power source.

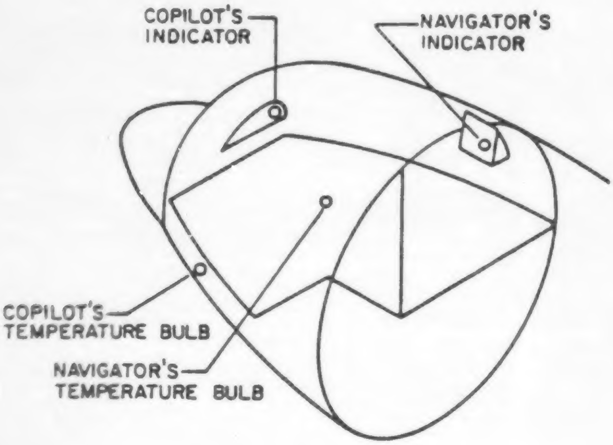

COPILOT'S INDICATOR
NAVIGATOR'S INDICATOR
COPILOT'S TEMPERATURE BULB
NAVIGATOR'S TEMPERATURE BULB

Figure 4.

Circle the letter of the correct response to the following statement(s).

1. The two resistance thermometer indicating systems are made up of

   a. one indicator, two temperature bulbs and one power source.

   b. two indicators, one temperature bulb and one power source.

   c. two indicators, two temperature bulbs and one power source.

   d. two indicators, two temperature bulbs and two power sources.

ANSWER TO FRAME 3: 1. c.

743

The resistance thermometer indicating system can also be used to indicate carburetor air temperature, oil temperature, cooling air temperature for electronic equipment, cargo compartment temperature, and cabin air temperature by using different temperature bulb designs.

NO RESPONSE REQUIRED

ANSWER TO FRAME 4: 1. c

Frame 6

The resistance thermometer temperature bulbs come in different shapes. Two of the most common shapes are shown in figures 5 and 6. The stem type bulb, shown in figure 5, can be used as a carburetor air temperature bulb or oil temperature bulb. The disc type bulb, shown in figure 6, is used as a free air temperature bulb. The bulbs are the sensing elements of the system.

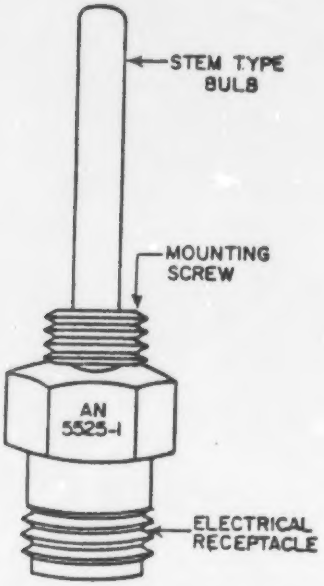

STEM TYPE BULB
MOUNTING SCREW
AN 5525-1
ELECTRICAL RECEPTACLE

Figure 5.

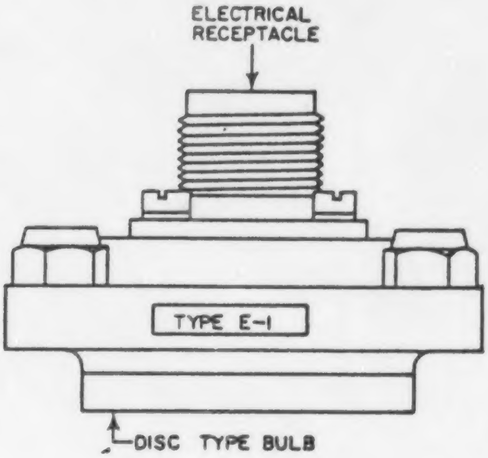

ELECTRICAL RECEPTACLE
TYPE E-1
DISC TYPE BULB

Figure 6.

Circle the letter of the correct response to the following statement(s).

1. The bulb shown in figure 6 can be used as

   a. a carburetor air temperature bulb.

   b. an oil temperature bulb.

   c. a carburetor or oil temperature bulb.

   d. a free air temperature bulb.

Electrically, the temperature bulbs are similar, since they all contain a resistance strip of fine nickel wire and a mica insulator. The mica insulates the wire from the temperature bulb. Nickel wire is used because its electrical resistance changes considerably with a small change in temperature. When its temperature increases, the resistance increases. When the temperature decreases, the resistance will decrease.

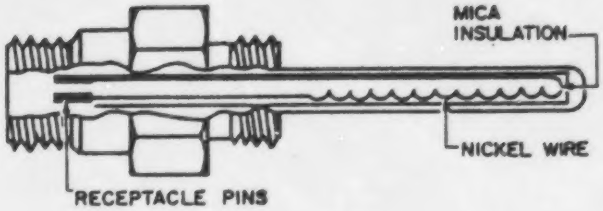


Figure 7.

Refer to figure 7 and circle the letter of the correct response to the following statement(s).

1. Nickel wire is used in the bulb because

    a. it will not burn out.

    b. it is more economical.

    c. its resistance is constant with temperature changes.

    d. it is sensitive to temperature changes.

ANSWERS TO FRAME 6: 1. d

Frame. 8

The indicator is the heart of the system. It is made up of a horseshoe magnet, a soft iron core, and two moving coils placed in the air gap of the horseshoe magnet (see figure 8). The soft iron core is stationary and the coils move around the core. The purpose of the soft iron core is to strengthen the magnetic field of the coils when current flows through them. It also sets up a low reluctance path for the lines of force of the horseshoe magnet.

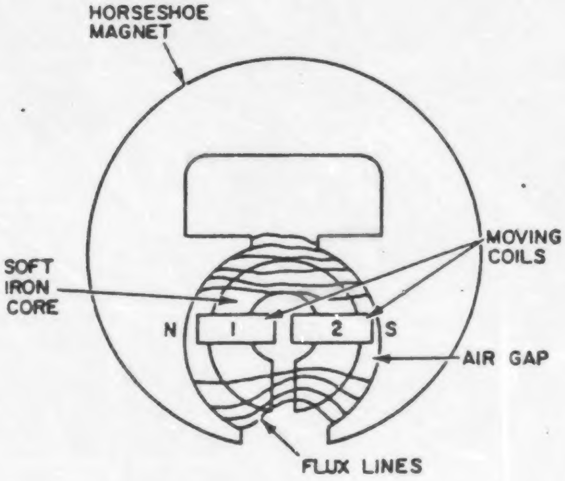


Figure 8.

Refer to figure 8 and circle the letter of the correct response to the following statement(s).

1. The purpose of the soft iron core is to

   a. strengthen the field of the coils.

   b. weaken the field of the coils.

   c. set up a magnetic field in the coils.

   d. set up the magnetic poles of the horseshoe magnet.

ANSWERS TO FRAME 7: 1. d

Frame 9

The moving coils are cemented together and electrically insulated from each other. The coils, springs (hairsprings), and pointer are mounted on a shaft (see figure 9). The springs are connected to the coils. These springs are used to conduct current to the coils and to carry the pointer to off scale cold when the power is disconnected.

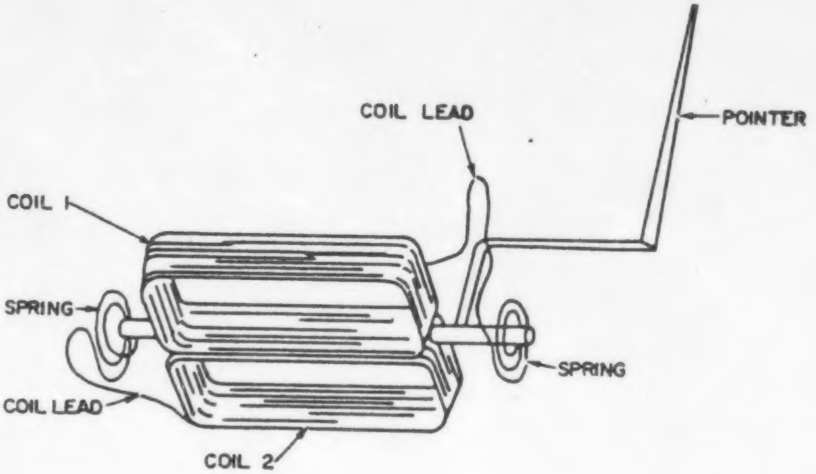


Figure 9.

Circle the letter of the correct response to the following statement(s).

1. The purpose of the springs (hairsprings) is to

   a. conduct current to the coils.

   b. move the pointer to off scale cold.

   c. move the pointer to off scale hot.

   d. conduct current to the coils and move the pointer to off scale hot when power is lost.

ANSWER TO FRAME 8: 1. a

Frame 10

An indicator, temperature bulb, and a DC power supply are connected together to form an indicating system. Coil 1, the variable current coil, is connected in series with the temperature bulb. Coil 2, the fixed current coil, is connected in series with a fixed resistor. Both coils are connected in parallel with the DC power source, and current flows through both parallel legs in the direction of the arrows shown in figure 10. Tie points A, B and C represent the electrical receptacle of the indicator.

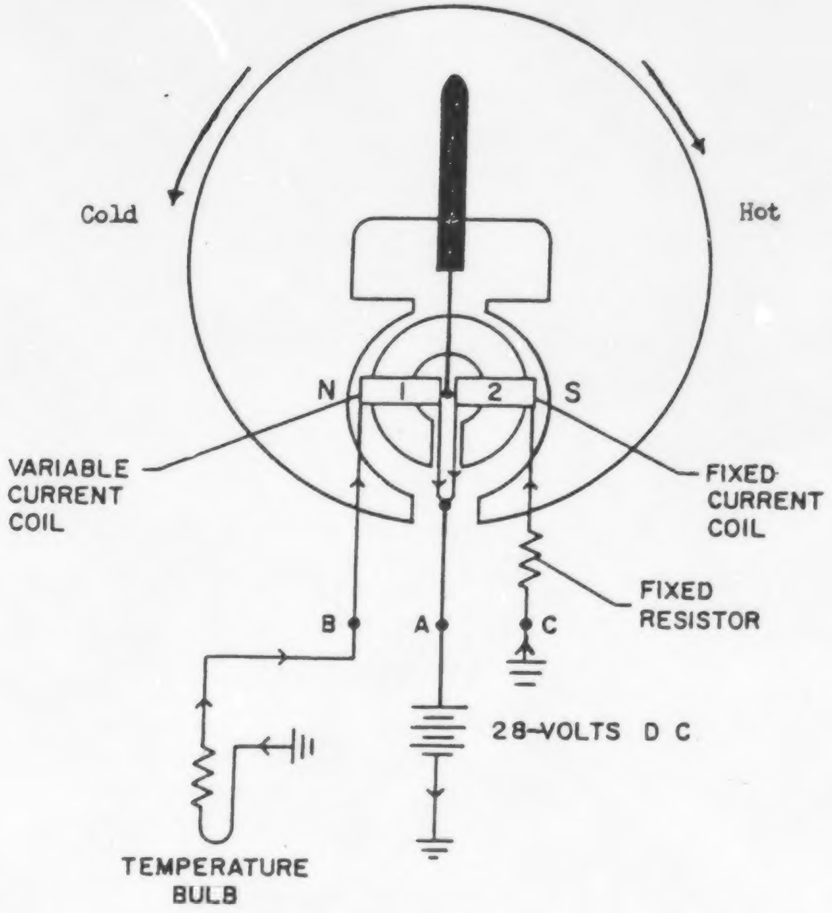

Cold
Hot
N
1
2
S
VARIABLE CURRENT COIL
FIXED CURRENT COIL
FIXED RESISTOR
B
A
C
28-VOLTS D C
TEMPERATURE BULB

Figure 10.

NO RESPONSE REQUIRED

ANSWER TO FRAME 9: 1. a and b

The indicator movement is essentially a ratiometer type because it operates on the principle of the ratio of current flow in coils 1 and 2. If an equal amount of current is flowing through each of the two coils, the magnetic field around each coil will be equal. Therefore, as the lines of force of the horseshoe magnet try to cross, an equal force is applied to each coil causing the coils to balance and the pointer to align at midscale. (See figure 11).

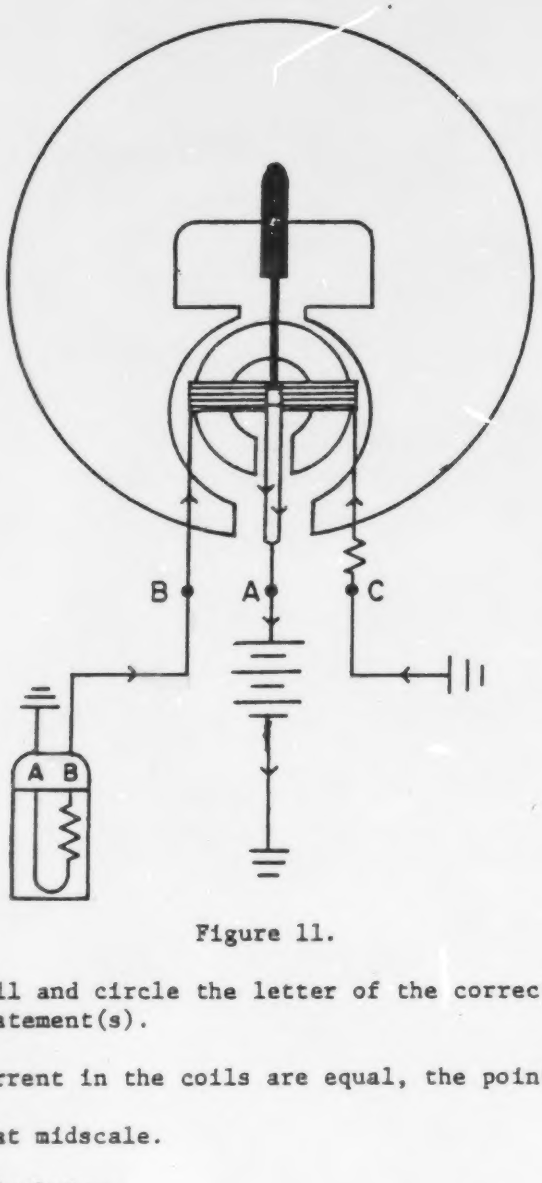


Figure 11.

Refer to figure 11 and circle the letter of the correct response to the following statement(s).

1. When the current in the coils are equal, the pointer will

   a. align at midscale.

   b. read clockwise.

   c. read counterclockwise.

730

2. The indicator is essentially the

   a. ratiometer type.

   b. self-synchronous type.

   c. AC powered type.

751

When the temperature at the bulb increases, the amount of current flow through coil 1 will decrease. With less current flow through the coil, the magnetic field around that coil will decrease. With a stronger field around coil 2 than around coil 1, greater force will be applied to coil 2. This unbalance causes the pointer to move to the right or upscale.

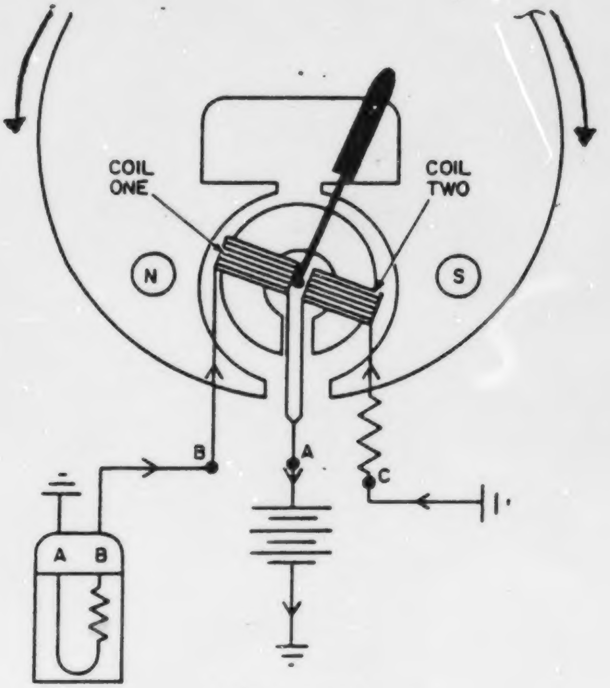


Figure 12.

Refer to figure 12 and circle the letter of the response to the following statement(s).

1. The current flow through the coils in figure 12 is

   a. less in coil 2 due to the increase of the resistor resistance in series with it.

   b. higher in coil 2 due to the decrease of the resistor resistance in series with it.

   c. less in coil 1 due to the increase of the bulb resistance in series with it.

   d. higher in coil 1 due to the increase of the bulb resistance in series with it.

ANSWERS TO FRAME 11: 1. a 2. a

732

ANSWERS TO FRAME 12: 1. c

Return to the beginning of the programmed text and review the objectives. When you are satisfied that you know and understand the material, you will take an appraisal.

3ABR32531 - After passing the appraisal you will proceed to the lab to perform on an actual resistance thermometer system.

3ABR32632B - After passing the appraisal you will proceed to Section B of thermometer indicating systems.

APPRAISAL

753

SECTION B. THERMOCOUPLE THERMOMETER
(3ABR32531 and 3ABR32632B)

Frame 1

It was found during the development of aircraft engines that high temperatures were developed in the cylinder heads of reciprocating engines. It was also found that higher temperatures were developed in the exhaust section of jet engines. It was determined that a remote monitoring system was needed to indicate the temperature of the cylinder head and exhaust gas systems for safe operation. The thermocouple thermometer system is used to measure the cylinder head temperature of the reciprocating engine and exhaust gas temperature of the jet engine.

Circle the letter of the correct response to the following statement(s).

1. The thermocouple thermometer is used to

   a. remotely indicate cylinder head or cabin temperature.

   b. directly indicate engine exhaust gas or engine cylinder head temperature.

   c. remotely indicate engine exhaust gas or engine cylinder head temperature.

   d. remotely indicate engine exhaust gas or cabin temperature.

Frame 2

The thermocouple is a device that converts heat into electricity. If both ends of two different types of wire are twisted or fused together and one of these junctions is either heated or cooled, a very small electrical voltage is developed in the circuit as long as the temperature difference is maintained. This small amount of voltage is measured in millivolts. The hot junction is the end located on the engine and the cold junction is in the instrument as shown in figure 13.

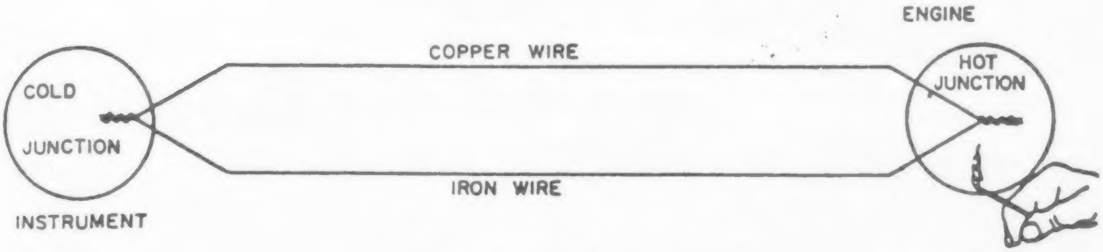


Figure 13.

Refer to figure 13 and circle the letter of the correct response(s) to the following statements.

1. Current flows in the thermocouple as long as

   a. both ends are cool.

   b. both ends are hot.

   c. one wire is cool and one wire is hot.

   d. one end is cool and one end is hot.

2. The voltage developed to operate this system is measured in

   a. volts.

   b. amps.

   c. millivolts.

   d. milliamps.

ANSWERS TO FRAME 1: 1. c

755

Frame 3

There are basically two types of thermocouple thermometer systems in use. One is used on reciprocating aircraft engines and the other one is used on jet aircraft engines. The following frames will show pictures of the parts of each system and explain the operation of each system. Figure 14 shows the units used on reciprocating engines and figure 15 shows the units used on jet engines.

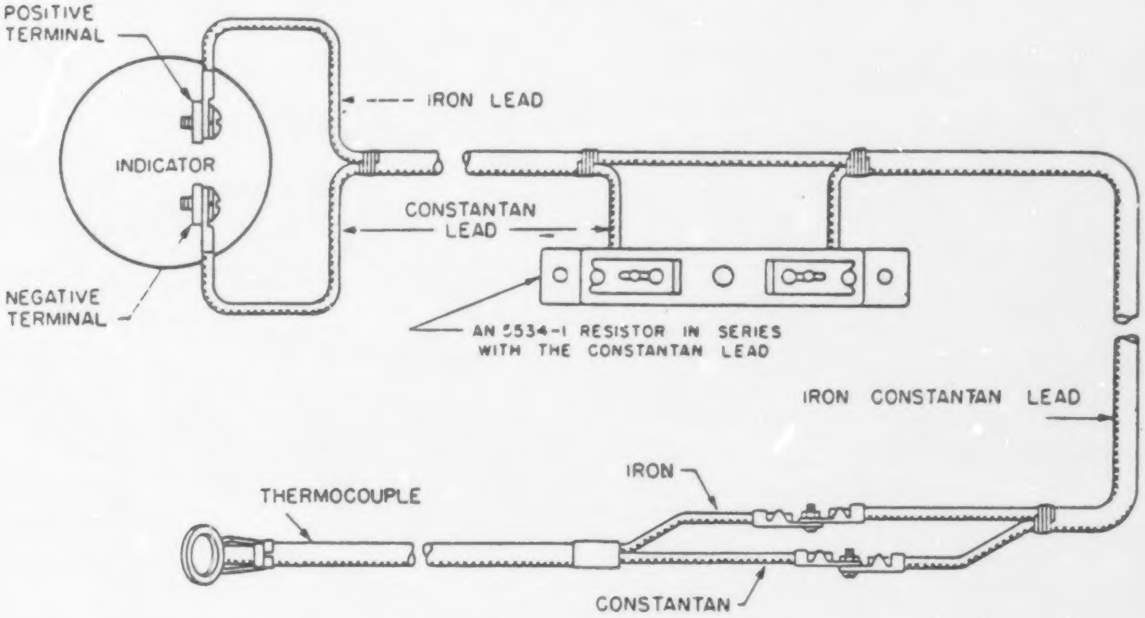

POSITIVE TERMINAL
IRON LEAD
INDICATOR
CONSTANTAN LEAD
NEGATIVE TERMINAL
AN 5534-1 RESISTOR IN SERIES WITH THE CONSTANTAN LEAD
IRON CONSTANTAN LEAD
IRON
THERMOCOUPLE
CONSTANTAN

Figure 14.

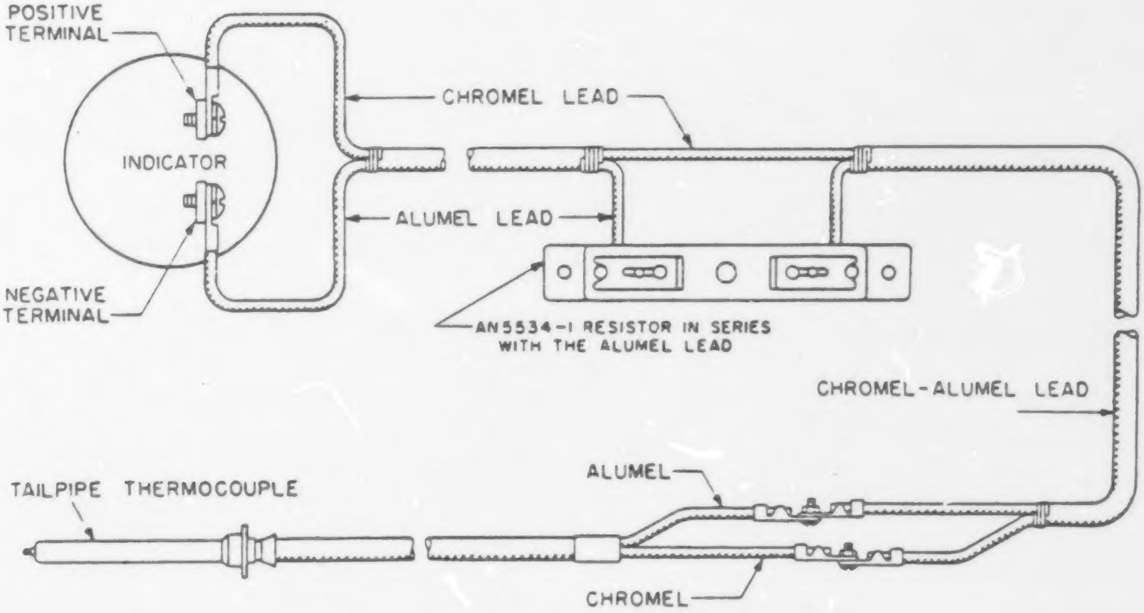

POSITIVE TERMINAL
CHROMEL LEAD
INDICATOR
ALUMEL LEAD
NEGATIVE TERMINAL
AN5534-1 RESISTOR IN SERIES WITH THE ALUMEL LEAD
CHROMEL-ALUMEL LEAD
ALUMEL
TAILPIPE THERMOCOUPLE
CHROMEL

Figure 15.

NO RESPONSE REQUIRED

ANSWERS TO FRAME 2: 1. d 2. c

736

Frame 4

The thermocouple thermometer indicator is basically a D'Arsonval millivoltmeter. Instead of the dial being calibrated to indicate millivolts it is calibrated in degrees Celsius. Figure 16 shows the type of indicator used with the cylinder head temperature system. Figure 17 shows the type of indicator used with the jet engine exhaust gas temperature system.

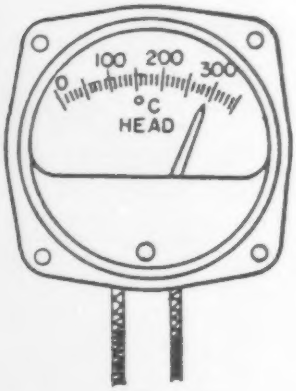


Figure 16.

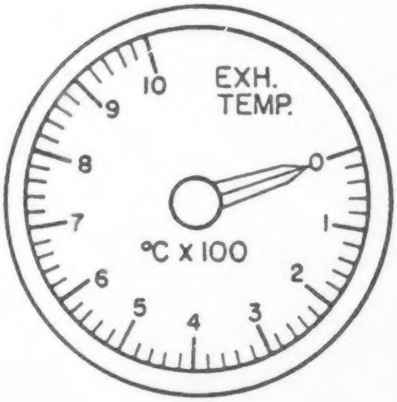


Figure 17.

Refer to figures 16 and 17 and circle the letter of the correct response(s) to the following statement(s).

1. The indicator in figure 16 is calibrated to indicate cylinder head temperature in

   a. degrees Fahrenheit.

   b. degrees Celsius.

   c. millivolts.

   d. milliamps.

2. The dial of the indicator shown in figure 17 is calibrated from

   a. 0 to 10 degrees C.

   b. 0 to 100 degrees C.

   c. 0 to 1000 degrees C.

   d. 0 to 10,000 degrees C.

There are several different types of thermocouples used in measuring engine temperatures. Figures 18 and 19 show two of these thermocouples. The thermocouple used on the reciprocating engine is either a gasket type as shown in figure 18 or a bayonet type. The leads are usually made of iron and constantan and are color coded. The iron lead has black insulation and the constantan lead has yellow insulation. These leads are used where engine temperatures do not exceed 300° Celsius. The thermocouple used in the jet engine has a probe as shown in figure 19. The leads are made of alumel and chromel and are also color coded. The alumel lead has green insulation and the chromel lead has white insulation. These leads are used where engine temperatures run as high as 1200° Celsius.

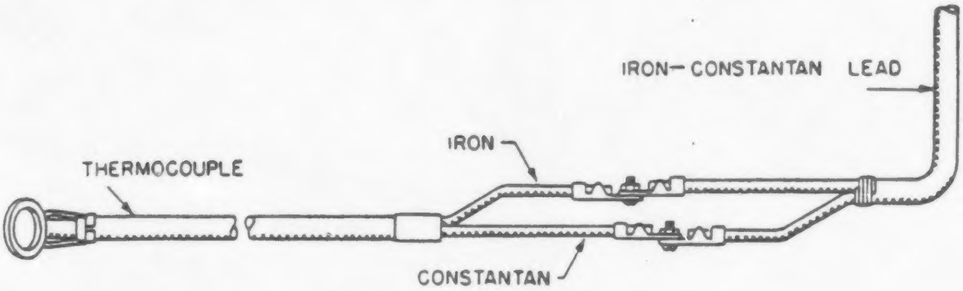


Figure 18.

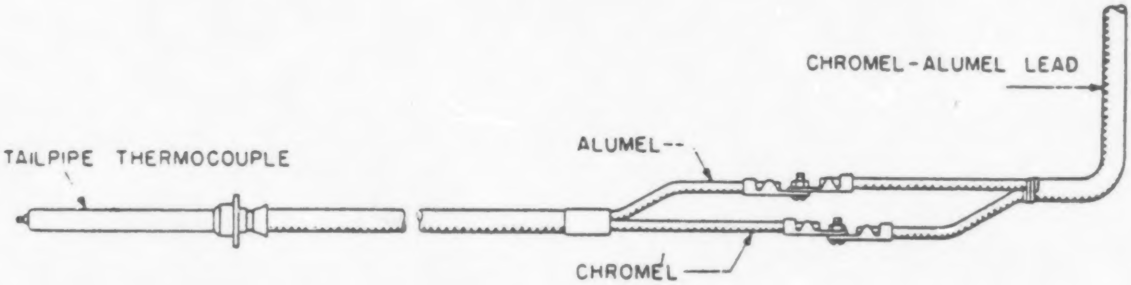


Figure 19.

Refer to figures 18 & 19 and circle the letter of the correct response to the following statement(s).

1. The thermocouple leads used on a reciprocating engine are
   - a. alumel-chromel.
   - b. alumel-iron.
   - c. chromel-constantan.
   - d. iron-constantan.
2. The insulation color for alumel-chromel leads are
   - a. white - yellow.
   - b. green - white.
   - c. green - black.
   - d. black - yellow.

ANSWERS TO FRAME 4: 1. b 2. c

738

Frame 6

The resistance of the thermocouple leads is 2, 8, or 22 ohms ± 0.1 ohm. Since practically no two aircraft use the same length wires, there has to be a way to adjust the overall resistance of the circuit. The wires cannot be cut as that would reduce the overall resistance of the leads and cause faulty readings. This means a variable resistor like the one shown in figure 20 must be used. The variable resistor can be adjusted to change the overall resistance of the circuit to within allowable tolerance.

Circle the letter of the correct response to the following statement(s).

1. The resistance of the thermocouple leads can be adjusted to within allowable tolerance by

   a. cutting the wires.

   b. using a variable resistor.

   c. splicing the wires to lengthen them.

ANSWERS TO FRAME 5: 1. d 2. b

750

Frame 7

Both thermocouple systems can use the same resistor. The resistor has two spools of wire, one of which is used as a spare. The wire on these spools is rated at 0.7 ohms per foot. The resistance of the leads is shown on the back of the instrument as shown in figure 20. To obtain the proper resistance for the circuit, wire is removed from one spool until the desired resistance of the circuit is obtained. The resistance of the circuit is always measured with the variable resistor in the circuit. A variable resistor is shown in figure 21.

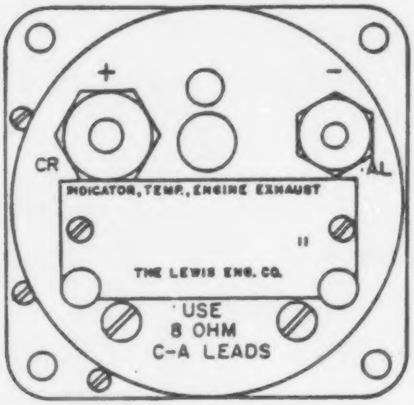

+
-
CR
AL
INDICATOR, TEMP., ENGINE EXHAUST
11
THE LEWIS ENG. CO.
USE
8 OHM
C-A LEADS

Figure 20.

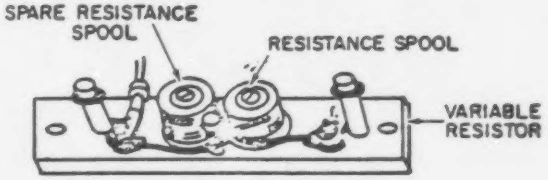

SPARE RESISTANCE
SPOOL
RESISTANCE SPOOL
VARIABLE
RESISTOR

Figure 21.

Refer to figure 20 and circle the letter of the correct response to the following statement(s).

1. The overall resistance of the circuit is 10 ohms. To obtain the correct amount of ohms for the indicator in figure 20 you would

   a. remove wire from the variable resistor.

   b. cut out a section of wire of the thermocouple.

   c. add a section of wire to the thermocouple.

   d. replace the thermocouple leads.

ANSWERS TO FRAME 6: 1. b

Frame 8

The resistor is placed in series with the negative lead of the thermocouple. The negative lead is determined by the color of the insulation. The negative lead of the thermocouple for the reciprocating engine is the constantan lead and has the yellow insulation. The negative lead of the thermocouple for the jet engine is the alumel lead and has the green insulation (as we have shown in figures 14 and 15.)

Circle the letter of the correct response to the following statement(s).

1. The variable resistor is placed in

   a. parallel with the negative lead.

   b. series with positive lead.

   c. parallel with positive lead.

   d. series with the negative lead.

2. The material and color code of the negative leads are

   a. alumel - yellow.

   b. constantan - yellow.

   c. alumel - green.

   d. constantan - white.

ANSWERS TO FRAME 7: 1. a

741

Frame 9

The jet engine has at least three thermocouples and sometimes more. The total number of thermocouples depends upon the design of the engine. These thermocouples are electrically connected in parallel. This is so that the average temperature of the engine exhaust gas is measured.

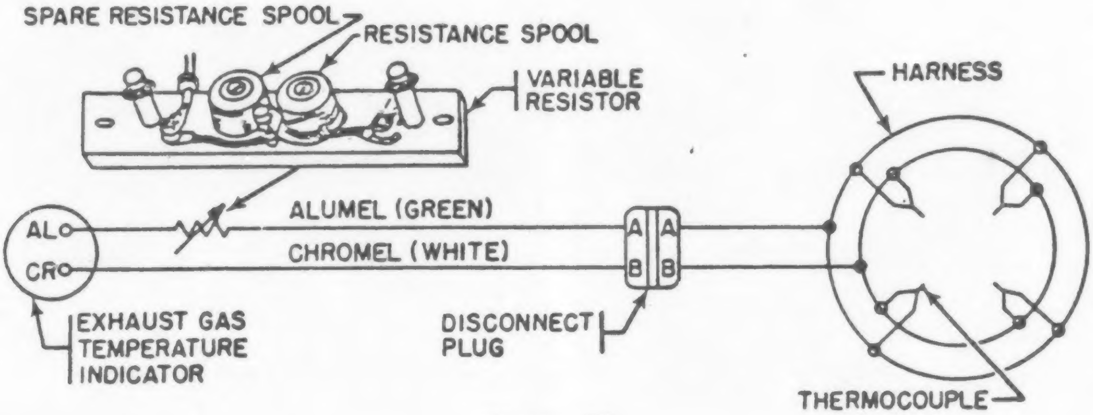

SPARE RESISTANCE SPOOL
RESISTANCE SPOOL
VARIABLE RESISTOR
HARNESS
AL
CR
ALUMEL (GREEN)
CHROMEL (WHITE)
A
A
B
B
EXHAUST GAS TEMPERATURE INDICATOR
DISCONNECT PLUG
THERMOCOUPLE

Figure 22.

Refer to figure 22 and circle the letter of the correct response to the following statement(s).

1. The thermocouples in a jet engine are connected in

   a. series.

   b. parallel.

   c. series-parallel.

ANSWERS TO FRAME 8: 1. d 2. b, c

762

742

ANSWER TO FRAME 9: 1. b

Return to the beginning of the programmed text and review the objectives. When you are satisfied that you know and understand the material, you will take an appraisal.

3ABR32531 - After passing the appraisal you will proceed to the lab to perform on an actual thermocouple thermometer system.

3ABR32632B - After passing the appraisal, you will proceed to Section C of temperature indicating system.

APPRAISAL

763

743

SECTION C. TURBINE INLET TEMPERATURE
(3ABR32632B ONLY)

Frame 1

Now that you have learned how a thermocouple probe operates, let's look at one specific type of system called the turbine inlet temperature system.

NO RESPONSE REQUIRED

764

744

Frame 2

The turbine inlet temperature indicating system indicates the simulated turbine inlet temperature. It would be desirable to sense actual turbine inlet temperature; however, the high amount of heat at this point makes it impractical. Also, serious engine damage could result if a probe should break and enter the turbine section. Turbine inlet temperature is indirectly measured through a thermocouple circuit which sums turbine discharge temperature and compressor discharge temperature and subtracts compressor inlet temperature. This is accomplished by six exhaust gas temperature thermocouple probes connected in parallel, two compressor inlet temperature thermocouple probes connected in parallel, and two compressor discharge temperature thermocouple probes connected in parallel. See foldout 1.

Circle the letter of the correct response to the following statement(s).

1. The thermocouple probes which subtract are

   a. compressor discharge temperature probes.

   b. turbine inlet temperature probes.

   c. compressor inlet temperature probes.

   d. turbine discharge temperature probes.

2. The thermocouple probes are connected in

   a. series.

   b. parallel.

   c. series-parallel.

785

Frame 3

The two compressor inlet temperature thermocouples are connected in reverse to the other thermocouples; therefore, compressor inlet temperature is subtracted from the remaining temperature signals. The results of all the temperatures are sent by an averaging circuit (one chromel lead and one alumel lead) to the engine turbine inlet temperature indicator (TIT). The color code and polarity for chromel is white and is positive, alumel is green and negative.

NO RESPONSE REQUIRED

ANSWERS TO FRAME 2: 1. c 2. b

Frame 4

The turbine inlet temperature indicator is located on the pilot's right main instrument panel, and provides the pilot with a continuous display of the turbine inlet gas temperature in degrees centigrade (°C). The indicator receives an electrical signal from the engine averaging circuit for simulated turbine inlet temperature. The face of the indicator consists of a drum type counter, which displays turbine inlet temperature, a scale which is graduated from 0 to 14 (°C X 100) with subdivisions equal to 50°C, a pointer which indicates turbine inlet temperature, and an off flag to indicate a loss of power. The indicator contains internal lighting which receives power from the instrument lighting circuit. Power to the turbine inlet temperature indicators is supplied from the 28V DC engine start bus.

Circle the letter of the correct response to the following statement(s).

1. Turbine inlet gas temperature is measured in

   a. degrees centigrade X 100.

   b. degrees Fahrenheit X 1000.

   c. degrees Celsius X 1000.

   d. electrical degrees X 1.

2. Turbine inlet temperature indicator power is

   a. 115V AC, 400Hz, 1 phase.

   b. 26V AC.

   c. 28V DC from engine start bus.

   d. 26V DC from engine start bus.

746

Frame 5

Use foldout 1 for the following frames. The turbine inlet temperature indicator is a self-balancing potentiometer type servo instrument that operates from millivolt signals produced by the engine thermocouple system. The signal voltage is applied to the indicator bridge circuit, where it is compared to a reference voltage signal. The difference between the two signals (error signal), is amplified to a level sufficient to drive a servo motor.

Circle the letter of the correct response to the following statement(s).

1. The signal voltage is applied to

   a. the servo assembly.

   b. the potentiometer.

   c. the amplifier.

   d. the bridge circuit.

ANSWERS TO FRAME 4: 1. a 2. c

Frame 6

The servo motor is geared to a rebalance potentiometer which adjusts the bridge circuit reference signal to equal that of the thermocouple. When both signals are equal, the bridge is balanced and the indicator is at rest. The servo motor shaft to the rebalance potentiometer is also coupled to the indicator pointer and drum counter through a gear train. The pointer is used to interpret the mechanical position of the potentiometer wiper arms and gives an indication in degrees centigrade.

Circle the letter of the correct response to the following statement(s).

1. The bridge circuit reference voltage is

   a. a fixed voltage.

   b. adjusted by the rebalance potentiometer.

   c. adjusted at the amplifier.

   d. adjusted to the back of the indicator.

ANSWER TO FRAME 5: 1. d

767

Looking at the whole system it operates as follows: When a temperature change is sensed by the thermocouple at the chromel-alumel junction, a DC voltage, proportional to the temperature change, is generated. This voltage is sent by the engine averaging circuit to the bridge circuit of the turbine inlet temperature indicator. This voltage is compared to the reference voltage and the difference is sent to the amplifier. From the amplifier the signal is sent to the servo motor which drives the pointer on the face of the indicator. The drum type counter is mechanically geared to the pointer shaft to give a digital readout of the pointer indication.

Circle the letter of the correct response to the following statement(s).

1. The voltage generated at the chromel-alumel junction is

   a. a fixed DC voltage.

   b. a DC voltage proportional to temperature changes.

   c. present only when temperature changes.

   d. a fixed AC voltage.

2. The drum type counter

   a. operates when temperature exceeds 1,000°C only.

   b. is electrically connected to the pointer.

   c. is independent of the pointer.

   d. is mechanically geared to the pointer.

ANSWER TO FRAME 6: 1. b

748

Frame 8

A self-test feature is incorporated in the turbine inlet temperature indicator. This is the only engine indicator that has this self-test feature. This self-test is accomplished by applying external power to the aircraft, and depressing the instrument self-test switch located on the ground check panel, which is situated over the left crew member's right shoulder. When this switch is depressed, the indicator will drive to a predetermined indication (1270 (±25) °C) within eight seconds, and the off flag will remain out of view.

> CAUTION: When performing this check on different aircraft, use applicable technical orders. DO NOT rely on your memory.

Circle the letter of the correct response to the following statement(s).

1. What indication should you observe when you depress the instrument self-test switch?

   a. The indicator will drive to 1200°C ± 25 and the off flag will remain out of view.

   b. The indicator will drive to 1200°C ± 25 and the off flag will be in view.

   c. The indicator will drive to 1270°C ± 25 and the off flag will remain in view.

   d. The indicator will drive to 1270°C ± 25 and the off flag will remain out of view.

ANSWERS TO FRAME 7: 1. b 2. d

780

Frame 9

Match the items in column "A" to the functions listed in column "B" by placing the correct letter in the proper blank.

"A"

1. ____ Indicator
2. ____ Thermocouple
3. ____ Self-test feature
4. ____ Off flag
5. ____ Reference voltage
6. ____ Servo motor
7. ____ Chromel-alumel
8. ____ Rebalance potentiometer

"B"

A. Materials used in manufacture of thermocouples.

B. Gives indication of turbine inlet temperature.

C. Indicates loss, or interruption of power.

D. Sensing device in the turbine inlet temperature system.

E. Compared to bridge circuit voltage, with resultant sent to the amplifier.

F. Adjusts reference voltage.

G. Mechanically repositions pointer and drum type counter.

H. Drives indicator to a predetermined value of 1270 ± 25°C.

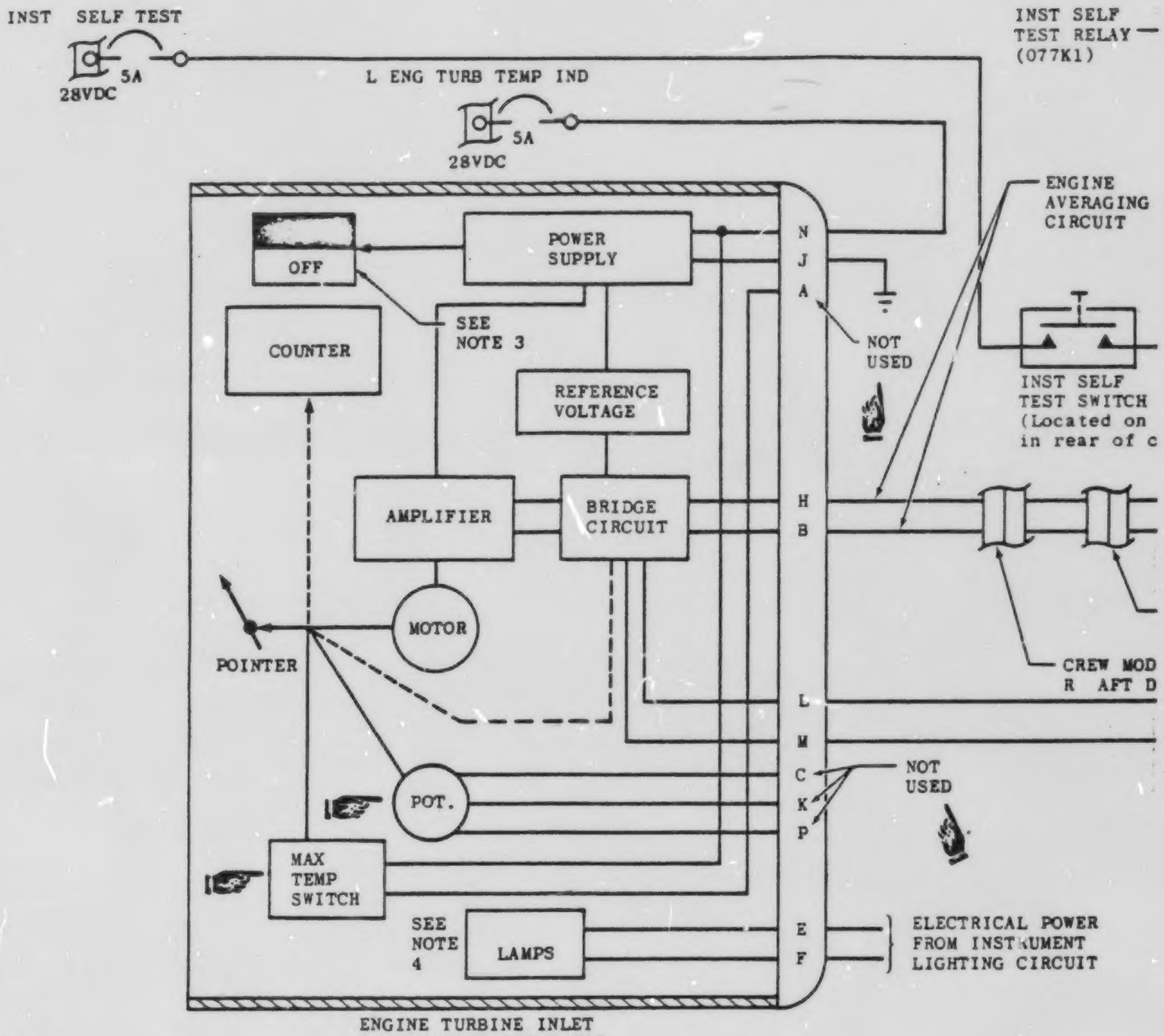
ANSWER TO FRAME 8: 1. d

ANSWERS TO FRAME 9: 1. B 2. D 3. H 4. C 5. E 6. G 7. A 8. F

Return to the beginning of the programmed text and review the objectives. When you are satisfied that you know and understand the material, you will take an appraisal.

After passing the appraisal you will proceed to the next topic of instruction.

APPRAISAL


INST SELF TEST
5A
28VDC
INST SELF
TEST RELAY
(077K1)
L ENG TURB TEMP IND
5A
28VDC
ENGINE
AVERAGING
CIRCUIT
OFF
POWER
SUPPLY
N
J
A
SEE
NOTE 3
NOT
USED
COUNTER
REFERENCE
VOLTAGE
INST SELF
TEST SWITCH
(Located on
in rear of c
AMPLIFIER
BRIDGE
CIRCUIT
H
B
MOTOR
POINTER
CREW MOD
R AFT D
L
M
C
K
P
NOT
USED
POT.
MAX
TEMP
SWITCH
SEE
NOTE
4
LAMPS
E
F
ELECTRICAL POWER
FROM INSTRUMENT
LIGHTING CIRCUIT
ENGINE TURBINE INLET
TEMPERATURE INDICATOR

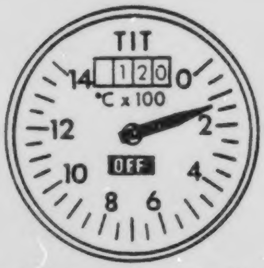
NOTES:

1. SYSTEM SHOWN IS FOR LEFT ENGINE IDENTICAL FOR RIGHT ENGINE EXCE SYSTEMS USE THE SAME INSTRUMENT RELAY.

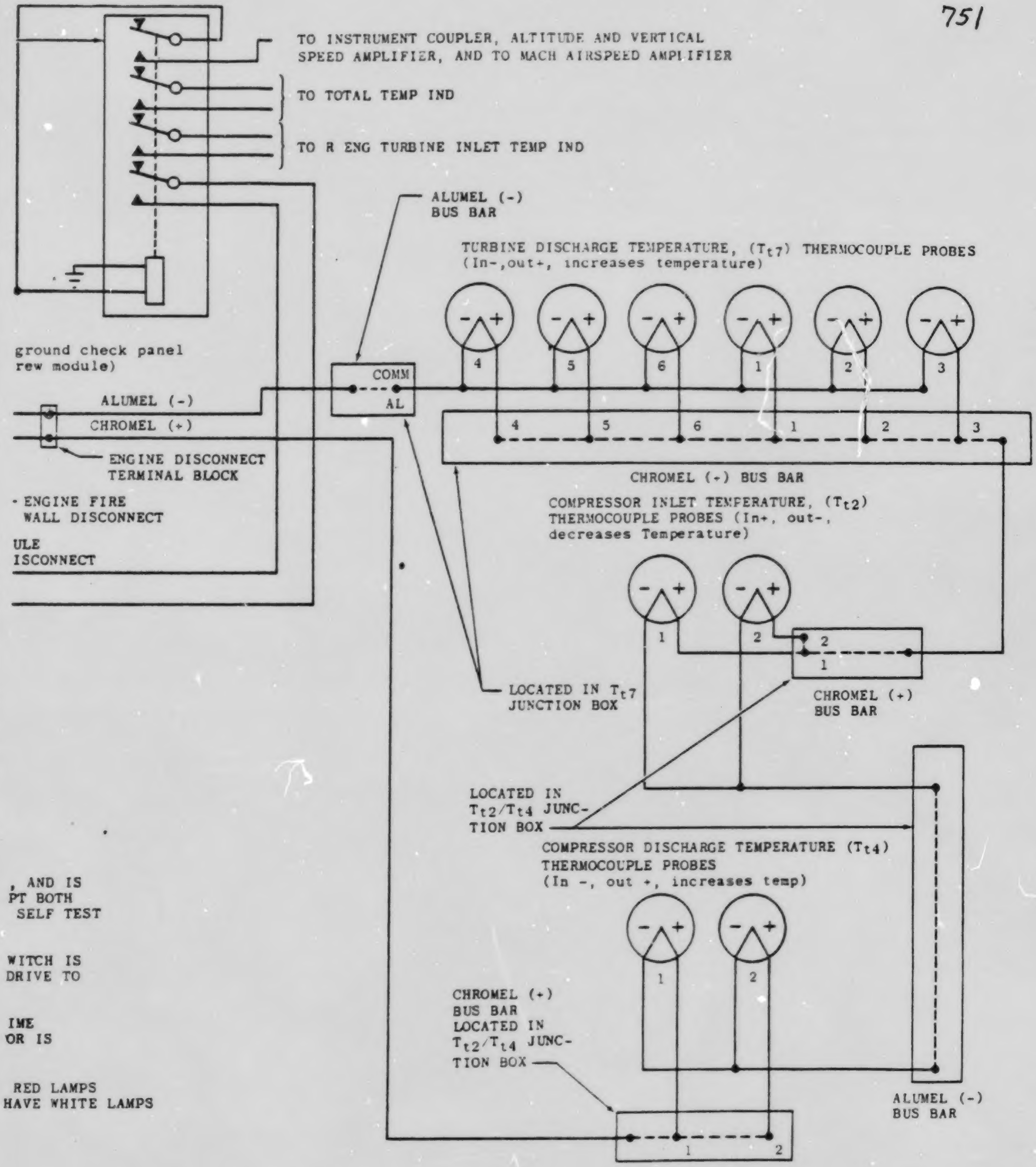
2. WHEN THE INSTRUMENT SELF TEST S DEPRESSED, THE INDICATOR SHALL 1270°C(±25°).

3. THE OFF FLAG SHALL APPEAR ANY T ELECTRICAL POWER TO THE INDICAT INTERRUPTED.

4. AF S/N 67-7193 THRU 68-281 HAVE AND AF S/N 68-282 THRU 69-6514


TIT
120
°C x 100
0
2
4
6
8
10
12
14
OFF

ENGINE TURBINE INLET
TEMPERATURE INDICATOR
(Reference)


TO INSTRUMENT COUPLER, ALTITUDE AND VERTICAL SPEED AMPLIFIER, AND TO MACH AIRSPEED AMPLIFIER
TO TOTAL TEMP IND
TO R ENG TURBINE INLET TEMP IND
ALUMEL (-) BUS BAR
TURBINE DISCHARGE TEMPERATURE, (T_{t7}) THERMOCOUPLE PROBES (In-, out+, increases temperature)
ground check panel
rew module)
COMM
AL
4
5
6
1
2
3
ALUMEL (-)
CHROMEL (+)
ENGINE DISCONNECT TERMINAL BLOCK
- ENGINE FIRE WALL DISCONNECT
ULE
ISCONNECT
CHROMEL (+) BUS BAR
COMPRESSOR INLET TEMPERATURE, (T_{t2}) THERMOCOUPLE PROBES (In+, out-, decreases Temperature)
LOCATED IN T_{t7} JUNCTION BOX
CHROMEL (+) BUS BAR
LOCATED IN T_{t2}/T_{t4} JUNCTION BOX
COMPRESSOR DISCHARGE TEMPERATURE (T_{t4}) THERMOCOUPLE PROBES (In -, out +, increases temp)
CHROMEL (+) BUS BAR LOCATED IN T_{t2}/T_{t4} JUNCTION BOX
ALUMEL (-) BUS BAR
- +

, AND IS
PT BOTH
SELF TEST

WITCH IS
DRIVE TO

IME
OR IS

RED LAMPS
HAVE WHITE LAMPS

Foldout 1. Engine Turbine Inlet Temperature Indicating System Schematic.

WORKBOOK
3ABR32531-WB-204

Technical Training

Avionics Instrument Systems Specialist

TEMPERATURE INDICATING SYSTEMS

18 July 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

Instrument/Flight Control Branch 3ABR32531-WB-204
Chanute AFB, Illinois

INSPECTION, OPERATIONAL CHECK, TROUBLESHOOTING, AND BENCH CHECK OF TEMPERATURE INDICATING SYSTEMS

SPECIAL INSTRUCTIONS:

WB-204 is written in TWO sections. Section A provides an outline for performing the inspection, operational check, troubleshooting procedures and bench check of the resistance thermometer indicating system. Section B provides the SAME for the thermocouple indicating system.

SECTION A
RESISTANCE THERMOMETER INDICATING SYSTEMS

OBJECTIVES

1. Given a workbook, tools, test equipment, and trainers, perform an inspection and operational check of temperature indicating systems with an accuracy of 100% correct workbook responses.

2. Given a workbook, test equipment, and trainers, troubleshoot temperature indicating systems with an accuracy of 100% correct workbook responses.

3. Given a workbook, test equipment, and trainers, bench check components of a temperature indicating system with an accuracy of 100% correct workbook responses.

EQUIPMENT

	Basis of Issue
3ABR32531-WB-204	1/student
Resistance Thermometer System Trainer	1/student
N-3A Thermometer Tester (81T27)	1/student
Liquid-In-Glass Thermometer	1/10 students
Wheatstone Bridge	1/student
Wheatstone Bridge Leads (Instructor's Desk)	2/student
Multimeter	1/student
TO 5E6-3-21-3 Extract	1/student
TO 33A1-12-15-1 Extract	1/student

PROCEDURE

CAUTION: Remove ALL JEWELRY before inspecting and performing the operational check, troubleshooting, and bench check.

USE CAUTION: When handling TEST equipment and trainer so as NOT to damage them.

Note: Obtain ALL necessary equipment BEFORE starting Lab.

Supersedes 3ABR32531-WB-204, 13 January 1975, and 3ABR32531-WB-206, 27 January 1975, which may be used until existing stocks are exhausted.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC-W - 300; TTVSR - 1

PART I. INSPECT THE RESISTANCE THERMOMETER SYSTEM

1. Visually inspect the indicator for condition by placing a checkmark (✓) on the proper blank.

	Satisfactory	Unsatisfactory
a. Security of mounting.		
b. Broken or loose glass.		
c. Broken or cracked glass.		
d. Condition of fluorescent markings and pointer.		

2. Visually check the temperature bulb for condition by placing a checkmark (✓) on the proper blank.

	Satisfactory	Unsatisfactory
a. Security of mounting.		
b. Cracks and dents.		

3. Visually inspect the wiring for condition by placing a checkmark (✓) on the proper blank.

	Satisfactory	Unsatisfactory
a. Broken wires.		
b. Frayed insulation.		
c. Damaged connectors.		

4. Visually inspect the circuit breaker for condition by placing a checkmark (✓) on the proper blank.

	Satisfactory	Unsatisfactory
a. Positive push-pull action.		
b. Loose terminals.		
c. Cracked or broken case.		

PART II. OPERATIONAL CHECK

1. To perform an operational check:

a. Make sure the circuit breaker is pulled OUT.

b. Make sure all trouble switches on the side of the trainer are in the OUT position.

c. Plug the trainer into the 28VDC outlet.

d. Indicator indicates (off scale cold _____), (room temperature _____), (off scale hot _____).

e. Push circuit breaker to the IN position.

f. Indicator indicates (off scale cold _____), (room temperature _____), (off scale hot _____).

g. Check the liquid-in-glass thermometer, located at the far right end of work bench, for ambient temperature (room temperature in centigrade).

h. Compare indicator reading with liquid-in-glass thermometer reading. The indicator reading should be within two (±2) degrees of the thermometer.

Satisfactory _____ Unsatisfactory _____

i. Place the palm of your hand over the temperature bulb.

(1) Temperature indicator shows an increase _____, decrease _____, remains the same _____.

j. Remove the plam from the temperature bulb.

(1) Temperature indicator shows an increase _____, decrease _____, remains the same _____.

PART III. TROUBLESHOOTING

1. Place trouble switch #1 to the IN position.

a. Indicator indicates (off scale cold _____), (room temperature _____), (off scale hot _____).

2. Place trouble switch #1 to the OUT position and place trouble switch #2 to the IN position.

a. Indicator indicates (off scale cold _____), (room temperature _____), (off scale hot _____).

3. Place trouble switch #2 to the OUT position and trouble switch #3 to the IN position.

a. Indicator indicates (off scale cold _____), (room temperature _____), (off scale hot _____).

4. Place trouble switch #3 to the OUT position and place trouble switch #4 to the IN position.

a. Indicator indicates (off scale cold _____), (room temperature _____), (off scale hot _____).

5. Place trouble switch #4 to the OUT position and place trouble switch #5 to the IN position.

a. Indicator indicates (off scale cold _____), (room temperature _____), (off scale hot _____).

6. Place trouble switch #5 to the OUT position and place trouble switch #6 to the IN position.

a. Indicator indicates (off scale cold _____), (room temperature _____), (off scale hot _____).

CAUTION: PULL CIRCUIT BREAKER AND DISCONNECT POWER PLUG FROM 28VDC OUTLET.

7. Using the multimeter, connect the red lead to the red receptacle and the black lead to the black receptacle.

8. Place function switch to Ohms.

9. Place range switch to Ohms X 1.

10. Short the red and black leads together and zero the multimeter using the OHMS ZERO ADJUST knob.

11. Disconnect FRONT and REAR electrical connector plugs on trainer.

12. Place trouble switch #6 to the OUT position and switch #1 to the IN position. Troubleshoot the system using the schematic provided on the trainer. Place a checkmark (✓) and response in the proper blank spaces.

Note: The trouble may be found between the connector plugs.

13. The location of the trouble is wire number __________.

14. The trouble is a (short _____), (an open _____), (crossed wires _____).

15. Place trouble switch #1 to the OUT position and switch #2 to the IN position.

16. The location of the trouble is wire number __________.

17. The trouble is a (short _____), (an open _____), (crossed wires _____).

18. Place trouble switch #2 to the OUT position and switch #3 to the IN position.

19. The location of the trouble is wire number __________.

20. The trouble is a (short _____), (an open _____), (crossed wires _____).

21. Place trouble switch #3 to the OUT position and switch #4 to the IN position.

757

22. The location of the trouble is wire number __________.

23. The trouble is a (short _____), (an open _____), (crossed wires _____).

24. Place trouble switch #4 to the OUT position and switch #5 to the IN position.

25. The location of the trouble is wire number __________.

26. The trouble is a (short _____), (an open _____), (crossed wires _____).

27. Place trouble switch #5 to the OUT position and switch #6 to the IN position.

28. The location of the trouble is wire number __________.

29. The trouble is a (short _____), (an open _____), (crossed wires _____).

30. Place trouble switch #6 to the OUT position.

31. Disconnect leads from multimeter. Put leads and meter back in CABINET.

32. Give this workbook to your instructor.

33. Instructor's Signature ______________________________

PART IV. BENCH CHECK

1. Set up the N3A Thermometer Tester, first, by placing switch #2 to -10 position. Switch #7 and #3 to the OFF position.

2. Refer to EXTRACT of TO 5E6-3-21-3, Section III, paragraphs 3-2 and 3-3, attached to the back of this workbook for OPERATION of TESTER.

3. Turn Temperature Selector Switch #2 to the temperature settings corresponding to TEST POINTS listed in figure 4-3 of TO 5E6-3-21-3.

NOTE: Be sure that the tester's voltmeter reads 28.5VDC for each temperature selected.

4. Record tthe actual indications in the following blanks and place a checkmark (✓) in the blank indicating whether the indicator is satisfactory or unsatisfactory.

773

5. ACTUAL INDICATION	SATISFACTORY	UNSATISFACTORY

6. After you have completed the 28.5VDC check, refer to paragraph 3-4g of TO 5E6-3-21-3.

7. Turn the temperature selector switch "2" to the temperature settings corresponding to the test points listed in figure 4-3 of TO 5E6-3-21-3.

NOTE: Be sure that the tester's voltmeter reads 22.5VDC for each temperature selected.

8. ACTUAL INDICATION	SATISFACTORY	UNSATISFACTORY

9. After completing the reduced voltage checks, turn switch "7" to the OFF position.

10. Turn temperature selector switch "2" to the OFF position.

11. Disconnect tester from indicator and reconnect indicator electrical connector.

12. Stow the tester leads back in the tester and put it back on the shelf.

BENCH CHECK OF THE RESISTANCE BULB

1. Disconnect temperature bulb electrical connector plug.

2. The resistance of the bulb is 90.38 ohms at 0 degrees centigrade.

3. For each degree of temperature change, the resistance of the bulb changes .358 ohms.

NOTE: Check ambient room temperature since an increase in ambient temperature causes an increase in resistance of the bulb.

4. Check the ambient room temperature by taking a reading on the liquid-in-glass thermometer. The instructor will show you where the thermometer is located.

5. Ambient temperature is __________ degrees centigrade.

6. Multiply the ambient temperature by 0.358 ohms and add this to 90.38 ohms that the bulb has at zero degrees centigrade. This will give the actual resistance of the bulb at ambient temperature.

The resistance is __________ ohms.

7. Connect the Wheatstone bridge leads to the temperature bulb and to X1 and X2 post on the Wheatstone bridge. Don't use the alligator clips.

8. Position GA knob to the RVM position.

9. Position BA knob to the INT position.

10. Position the RES-VAR-MUR knob to the RES position.

11. Position the "MULTIPLY BY" switch IAW the chart located in TO EXTRACT 33A1-12-15-1, paragraph 14a(2)(c), according to your resistance in Step 6.

12. Push the galvanometer pointer lock button toward dial to unlock the galvanometer pointer.

13. Turn the zero adjust knob located above the lock button until the galvanometer pointer is at zero.

14. Follow the instructions in paragraphs 14b(1) and (2) of TO 33A1-12-15-1 EXTRACT for measuring resistance of the temperature bulb. Be sure to follow the chart in paragraph 14.

15. The resistance of the bulb is __________ ohms.

16. Place the EXT, BA, INT switch to EXT position.

17. Push the galvanometer lock button toward the zero adjust knob to lock the pointer.

18. Disconnect the test leads.

19. Reconnect trainer electrical connector plugs.

20. Put trainer and test equipment away.

21. Hand this workbook to the instructor.

22. Student's Last Name ______________.

SECTION B
THERMOCOUPLE THERMOMETER SYSTEM

EQUIPMENT

	Basis of Issue
Thermocouple Trainer (Exhaust Gas Temperature)	1/student
Jet Cal Tester	1/student
Multimeter	1/student
N-3A Thermometer Tester	1/student
TO 33D2-6-13-21 EXTRACT	1/student
Common Screwdriver	1/student

PROCEDURE

CAUTION: Remove ALL JEWELRY. DO NOT damage thermocouple thermometer while handling it. Use CAUTION when using test equipment, so as not to damage it. Use EXTREME CAUTION when using the JET CAL TESTER as the heaters and thermocouples are EXTREMELY HOT. TO EXTRACTS are attached to the back of this workbook. When using TO EXTRACTS, read only directed references. Some parts of the TOs are not necessary for completing this project.

PART I. INSPECTION

1. Visually inspect the indicator for the following conditions by placing a checkmark (✓) on the proper blank.

	SATISFACTORY	UNSATISFACTORY
a. Security of mounting.	____________	____________
b. Broken or loose glass.	____________	____________
c. Damaged case.	____________	____________
d. Condition of dial and pointer.	____________	____________

2. Visually inspect the wiring for the following condition, by placing a checkmark (✓) on the proper blank.

a. Frayed wires.	____________	____________
b. Broken wires.	____________	____________
c. Loose terminals.	____________	____________

3. Visually inspect wiring harness and thermocouples for condition by placing a checkmark (✓) on the proper blank.

a. Connector for security.	____________	____________
b. Connectors and harness for damage.	____________	____________
c. Bent or broken thermocouples.	____________	____________
d. Variable resistor for dents or cracks.	____________	____________

PART II. OPERATIONAL CHECK

1. Adjust EGT indicator to ambient (room) temperature, using the screwdriver to turn the adjustment on the back of the indicator.

2. Perform the EGT system functional check by referring to instructions in the lid of the jet cal tester, items 1 through 11.

NOTE: Hang heater probe over back of work bench while heating heater to 500°C.

CAUTION: Set the degree Centigrade scale at ambient temperature and as the temperature of the probe increases, increase the temperature setting of the degree centigrade scale knob so as to keep galvanometer #1 pointer between the figure 10 on the left and zero on the galvanometer scale.

a. As the 475° Centigrade mark comes into view on the degree Centigrade scale, set the degree Centigrade scale at 500° then start slowly turning the temperature regulator counterclockwise until the galvanometer is ZEROED at 500°C.

CAUTION: Always keep galvanometer pointer on the lighted scale to prevent damage to galvanometer.

NOTE: Call instructor to aid you in performing heat rise check.

b. Heat rise indication on ALL FOUR thermocouples is Satisfactory ____, Unsatisfactory _____.

3. CONNECT the other three (3) heaters to the junction box.

a. PLACE heater probes over thermocouples on EACH side of trainer.

b. Be SURE the insulation DOES NOT touch the heaters or thermocouples.

c. Follow instructions in the lid of the jet cal tester (12 to 18) for the EGT indicating system.

4. After temperature has stabilized, check the EGT indication against the degree Centigrade scale on the tester.

a. EGT indicator should read 500° (plus ambient temperature) ± 20 degrees tolerance.

b. System is Satisfactory _____, Unsatisfactory _____.

PART III. TROUBLESHOOTING

1. Place trouble switch #1 to the IN position.

a. Indicator reads high _____, low _____, ambient temperature _____.

2. Place trouble switch #1 to the OUT position and place trouble switch #2 to the IN position.

a. Indicator reads high _____, low _____, ambient temperature _____.

3. Place trouble switch #2 to the OUT position and place trouble switch #3 to the IN position.

a. Indicator reads high _____, low _____, ambient temperature _____.

4. Place trouble switch #3 to the OUT position.

5. Place SW-6 to the mechanical zero position.

6. Turn temperature regulator fully counterclockwise to Zero.

7. Place SW-1 to OFF position and set degree Centigrade knob to 21°C.

8. Disconnect power cable from electrical supply and from tester. Replace cap on receptacle.

9. Disconnect heater cable from tester and junction box and replace cap on receptacle on tester.

10. Stow all cables in bottom of tester.

11. Disconnect heater probe leads from junction box and stow junction box in the bottom of the tester.

12. Remove heaters from thermocouples and stow heaters in special rack in the top of the tester.

CAUTION: Heaters are still HOT. Do NOT touch the metal.
DO NOT damage heaters or thermocouples.

13. Disconnect leads from indicator.

14. Place TC switch on trainer to OUT position.

15. Connect leads to multimeter and zero multimeter on X1 range scale.

16. Check the readings between the wires. (Normal Readings.) Positive wire reads _____ ohms. Negative wire reads _____ ohms. Positive lead to negative lead is _____ ohms.

a. Troubleshoot between terminal bus and disconnected leads from indicator.

17. Place trouble switch #1 to the IN position. The trouble is: Circle correct response and fill in OHMS Value for that trouble.

a. An open wire. _____ ohms.

b. High resistance. _____ ohms.

c. Shorted wires. _____ ohms.

18. Place trouble switch #1 to the OUT position and place trouble switch #2 to the IN position. The trouble is:

a. An open wire. _____ ohms.

b. High resistance. _____ ohms.

c. Shorted wires. _____ ohms.

19. Place trouble switch #2 to the OUT position and place trouble switch #3 to the IN position. The trouble is:

a. An open wire. _____ ohms.

b. High resistance. _____ ohms.

c. Shorted wires. _____ ohms.

20. Place trouble switch #3 to the OUT position.

21. Disconnect leads from multimeter and turn function switch to DC volts and the range switch ALL the way to the RIGHT.

22. Put multimeter back in the cabinet.

PART IV. BENCH CHECK

1. Obtain a N-3A thermometer tester from bottom shelf.

2. To PREVENT DAMAGE to the indicator during test, check the N-3A thermometer tester to make sure that the switch numbers 2, 7, and 3 are turned to the OFF position before connecting tester to thermocouple indicator.

3. REFER to EXTRACT of TO 33D2-6-13-21, Section IV, paragraphs 4-2 through 4-5 and figure 1 for operation of the N-3A thermometer tester.

a. For BENCH CHECK of the indicator, read paragraphs 4-8 and 4-9 and follow the steps of the worksheet.

b. Look at back of indicator for system resistance.

c. Read only those portions of paragraphs that have HEAVY VERTICAL LINES along the border.

4. Scale Error Test

a. DO NOT tap glass, tap indicator before recording each reading.

b. Add ambient temperature to switch #2 readings.

Test Point	Tolerance	Satisfactory	Unsatisfactory
200°C	± 30°C		
400°C	± 20°C		
500°C	± 20°C		
600°C	± 10°C		
700°C	± 5°C		
800°C	± 10°C		
1000°C	± 20°C		

3. Friction Error Test

Note: The reading shall be noted at each test point before tap and after tap. Tap the indicator lightly.

Check Point	Before Tap	After Tap	Tolerance	S	U
200°C			± 15°C		
500°C			± 15°C		
700°C			± 15°C		
1000°C			± 15°C		

4. Position Error Test

a. Move the indicator to the positions listed in the following chart.

Check Point	Right Bank 90°	Tolerance /-	Satisfactory	Unsatisfactory
700°C		± 25°C		
	Left Bank 90°			
700°C		± 25°C		
	45° Climb			
700°C		± 25°C		
	45° Dive			
700°C		± 25°C		

5. Zero Adjust Test

a. Set the indicator on 700°C and operate the zero adjust screw on the back of the indicator. The pointer on the indicator shall not move less than 40°C above and below the 700°C reading. The total motion of the pointer shall not exceed 200°C.

b. The indicator is satisfactory _____, unsatisfactory _____.

6. Reset the pointer to the 700°C mark on the indicator.

7. Turn 30-position and the 8-position switch to OFF.

8. Disconnect the test equipment.

Note: Connect leads to proper terminal posts and place TC switch to "IN" position.

9. Put trainer and test equipment away.

10. Student's Name ________________________________

SECTION III

TEST PROCEDURE

3-1. CALIBRATING PROCEDURE.

a. There are two methods of calibrating the Ratiometer described herein. The first method requires a decade resistance box, rheostat, and direct-current voltage supply as shown in figure 3-1. With this method, the decade resistance box is adjusted to the resistance required to deflect the Ratiometer pointer to each calibration point. See figure 3-2.

b. The second method of calibrating the Ratiometer requires the use of the 81T27 Tester. In this Tester, precision resistors are selectively switched into the bulb arm of the circuit by means of the temperature selector switch. The resistances selected by this switch correspond to the values given in figure 3-2. The voltage required is supplied by an internal battery, is adjusted by a rheostat, and is indicated on the self-contained voltmeter. Complete directions are furnished with each Tester.

c. The following instructions are based on the use of the Tester. If a Tester is not available, substitute the decade resistance box set-up and follow values of figure 3-2.

3-2. Connect Ratiometer to 81T27 Tester, using the four-pin adapter supplied with the Tester. Item numbers in quotes are identification numbers engraved in the panel of the Tester. Turn switch "8" to "LEFT & SINGLE". Turn switch "7" to 24v and adjust rheostats "5 and 6" until voltmeter "1" indicates 28. 5 volts. These preliminary steps are to be followed for all test readings except that, when performing the reduced voltage test (paragraph 3-5, g), rheostat is to be adjusted until voltmeter indicates 22. 5 volts.

3-3. Turn temperature selector switch "2" to temperature points corresponding to test points listed in figure 4-3 and record reading of Ratiometer.

NOTE

Always tap Ratiometer lightly when taking readings, and be sure to hold it in the normal operating position.

Ratiometers found to be within tolerance and needed no further adjustment may be sealed and evacuated.

3-4. CALIBRATION ADJUSTMENTS; POTENTIOMETERS.

a. Make first adjustment at center of scale. With Ratiometer connected as in paragraph 3-1, turn Tester temperature switch to 0°C and note pointer reading. Adjust pointer to read 0°C by turning the centering potentiometer (see figure 2-9). Use a soldering iron to shift potentiometer clips on slidewire. Be certain clip is securely soldered to slidewire after adjustments.

b. Turn temperature switch to -70 and +50 and note readings. Readings will indicate whether scale ends should be expanded or contracted. For example, if pointer goes to -68 at low end of scale and +48 at high end, the scale ends should be expanded. Turn expansion potentiometer (see figure 2-9) to expand scale ends. Occasionally it will be necessary to readjust the centering potentiometer after adjusting scale ends.

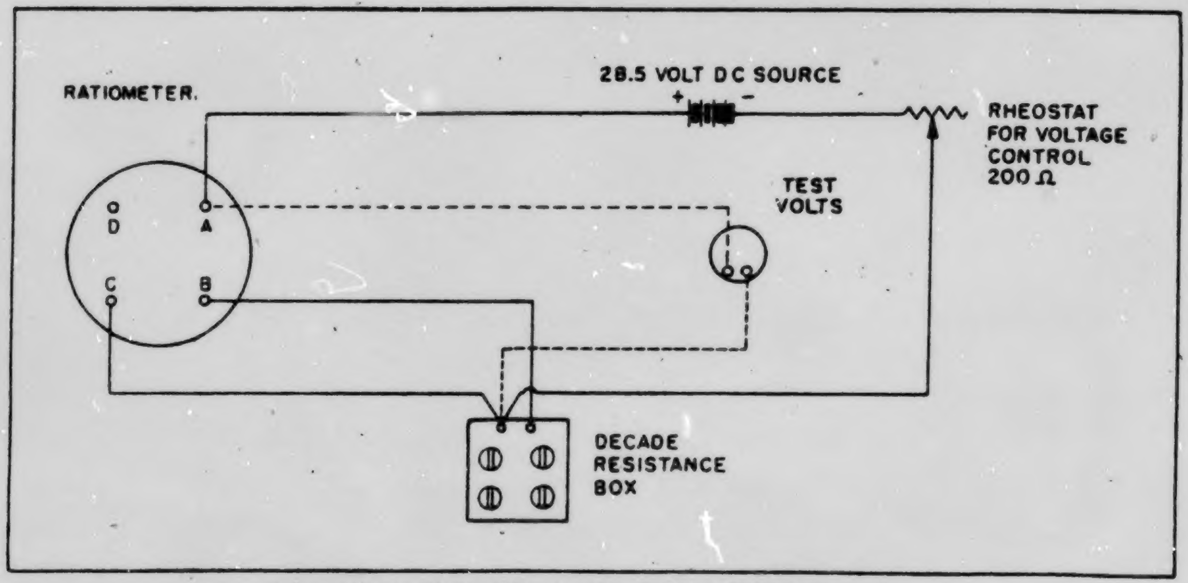


Figure 3-1. Wiring Diagram for Testing Ratiometer with Decade Resistance Box

g. When correct readings have been obtained at all points with 28.5 volts applied, lower the voltage to 22.5 volts and take a set of readings. The readings obtained with 22.5 volts applied may vary from the corresponding readings with 28.5 volts applied. Variation tolerances are listed in figure 3-2 under "Reduced (22.5 Volts)". For example, if the observed error at +10 was one degree with 28.5 volts applied, then the error permissible at this point would be two degrees with 22.5 volts applied.

h. When all calibration procedures have been completed, make a final visual inspection of the Ratiometer to be certain that no foreign particles are in the movement and that all connections are securely soldered. Fasten the case assembly (11, figure 2-4) and shield (10) to the base assembly (39) with case retaining screws (12) and shield retaining screws (6). Ratiometers are now ready for sealing, evacuation, and helium filling procedures.

3-6. FINAL LEAK TEST.

a. Place Ratiometer in desiccator jar, cover it with water, and connect desiccator jar to vacuum pump, gage, and two-way valve as shown in figure 3-3.

b. Close valve "B" and open valve "A". Draw a vacuum slightly greater than 25mm of mercury (about one inch) for one minute, or until the water ceases to give off air bubbles, whichever is longer.

c. Close valve "A" and slowly open valve "B" allowing pressure to increase to 63 mm of mercury (about two and one-half inches), then close valve "B".

d. Examine Ratiometer carefully for leaks, watching for a continuous flow of bubbles coming from within the case. Do not confuse bubbles which are a result of entrapped air on various parts of the case with bubbles caused by a leak.

d. Slowly open valve "B" until pressure in the jar rises to atmospheric.

WARNING

Valve "B" must be opened SLOWLY; otherwise the sudden inrush of air would blow the lid off the jar.

e. Dry the Ratiometer thoroughly by blowing with compressed air and placing it in a 70°C (158°F) oven for thirty minutes.

f. If a leak was observed, repair it according to instructions given in paragraph 2-18.

3-7. FINAL OPERATIONAL TEST.

a. This test is to be performed on completely-sealed Ratiometers to insure satisfactory operation before shipment, storage, or installation.

b. Connect Ratiometer to 81T27 Tester or decade resistance box set-up. Take a scale-error test at all points designated on figure 3-2 as instructed in paragraphs 3-2 to 3-3.

c. While the Ratiometer is connected to test equipment, check position error as instructed in paragraph 2-13, e.

3-8. PACKING AFTER OVERHAUL.

a. Use Specification PPB-B-636 Type I, Class I carton 7-1/2 x 7-1/2 x 7-1/2 inches. Insert a pad of eight inch wide by five foot long by one-half inch thick, Specification PPP-C-843A Type 2, crepe cullulose wadding in bottom of carton.

b. Wrap indicator in crepe cellulose wadding three inches wide by ten foot long by one-half inch thick and place in carton.

c. Place another pad of eight inch wide by five foo long by one-half inch thick crepe cellulose wadding c top of indicator.

d. Seal carton with Specification UU-T-16 tape.

NOTE

To prevent damage to jewels and pivots, NEVER ship a Ratiometer unless it has a minimum of two inches of cushioning material on all sides.

ELECTRICAL RESISTANCE TYPE THERMOMETER

Part No. 162B3

THE INSTRUCTIONS CONTAINED IN PRECEDING SECTIONS OF THIS HANDBOOK APPLY EXCEPT FOR THE DIFFERENCES LISTED IN THIS DATA SHEET.

LEADING PARTICULARS

Scale Range	-70 to +150°C
Mask Marking	Surface Temp.
Operating Voltage	28.5 Volts dc
Bulb Curve	90.38 ohms at 0°C(32°F)
Internal Wiring	See figure 2-9
Case	2-inch size
Mounting	Ring-Clamp, Type A-1

SPECIAL TOOLS. Same as for 162B2.

DISASSEMBLY. Same as for 162B2.

CLEANING. Same as for 162B2.

INSPECTION. Same as for 162B2.

TESTING (during overhaul). Same as for 162B2, except follow applicable spool values in figure 2-7.

REPAIR OR REPLACEMENT. Same as for 162B2.

LUBRICATION. None permitted.

REASSEMBLY. Same as for 162B2.

BALANCING PROCEDURE. Same as for 162B2, except tolerance is + or -3.0°C.

SEALING AND GAS-FILLING PROCEDURES. Same as for 162B2.

FINAL LEAK TEST. Same as for 162B2.

TESTING (after overhaul). Same as for 162B2, except for the following:

a. For calibrating procedures with decade resistance box, use the same connections shown in figure 3-1, but use test points, resistances, and test tolerances in figure 4-3.

b. For calibrating procedures with 61T27 Tester, follow test points and tolerances given in figure 4-3.

Test Point Degrees Centigrade	Ohms	TOLERANCES ± DEGREES CENTIGRADE Normal (28.5 Volts)	*Reduced (22.5 Volts)
-70	68.27	4.0	3.0
-30	80.56	3.0	3.0
0	90.38	2.0	2.0
+30	100.91	2.0	2.0
+80	120.36	2.0	2.0
+120	137.78	3.0	3.0
+150	151.91	4.0	3.0

*These tolerances are with respect to readings observed at normal voltage.

Figure 4-3. Temperature vs Resistance Values and Test Tolerances

769

1 volt through 1 megohm. When using the 4½ volt internal battery, one megohm of resistance will cause the pointer to deflect 4½ scale divisions.

b. Shorts and Crosses. Wires in cable commonly arranged in pairs (A.fig.5). An electrical path between two wires of the same pair is commonly called a short. An electrical path between two wires of adjacent pairs is commonly called a cross (C,fig.5) Test for a short or a cross as follows:

(1) Prepare the test set (a(1)-(4) above.

(2) Disconnect all equipment from the far end of the cable.

(3) Connect one of the wires to be tested to the ground binding post and press the GA SENS 1 switch. Touch each of the other wires in the cable to line binding post X1. The galvanometer will deflect strongly when the other faulty wire contacts line binding post and will show no deflection with wires not shorted or crossed.

c. Open Conductor.

(1) Perform a(1) through (5) above.

(2) If the wires to be tested are in lead-covered cable, connect the far end of the wires in the cable to the cable sheath. If the cable is not lead-covered, connect the far end of the wires to a good ground.

(3) Press GA SENS 1 switch and touch each of the wires at the near end (one at a time) to line binding post X1. The galvanometer will deflect for all wires except any that are open.

14. MEASUREMENT OF LOOP OR UNKNOWN RESISTANCE

Measure the resistance of a loop (two lengths of wire joined at the distant end) or of any electrical component (resistors, transformers, etc.) as follows:

a. Preparation for Test.

(1) Adjust the galvanometer (par.10a)

(2) Position the test set controls (fig.3) as follows:

(a) GA switch to RVM.

(b) RES-VAR-MUR switch to RES.

(c) Make as close an estimate as possible of the resistance to be measured and set the MULTIPLY BY dial as indicated in the following chart:

Estimated resistance (ohms)	MULTIPLY BY dial setting
Below 10	$\frac{1}{1000}$
10 to 100	$\frac{1}{100}$
100 to 1000	$\frac{1}{10}$
1000 to 10,000	$\frac{1}{1}$
10,000 to 100,000	$\frac{10}{1}$[a]
100,000 to 1,011,000	$\frac{100}{1}$[a]

---

[a] To obtain more sensitive measurements (greater pointer deflections) when measuring resistances above 10,000 ohms, use an external 22½- or 45-volt battery (Battery BA-53) or equal.

(3) Make the following connections:

(a) If the resistance of a loop is to be measured, disconnect all equipment from the near end of the loop and connect one wire of the loop to line binding post X1 and the other wire to line binding post X2 (A, fig. 5). Be sure that the wires connected to the test set are clean and are firmly secured to the binding posts. Have all equipment disconnected from the far end of the loop and a short placed across the circuit at that end.

(b) If the resistance of an electrical component is to be measured, connect the component across line binding posts X1 and X2.

b. Balancing the Bridge.

(1) Position the thousands, hundreds, tens, and units decade dials (fig. 3) to settings that total the estimated

790

resistance to be measured divided by the setting of the MULTIPLY BY dial. From Step 6

Example: If the estimated resistance to be measured is 500 ohms, the setting of the MULTIPLY BY dial must be 1/10 (chart in a above); therefore the positions of the decade dials must total 5,000.

$$\frac{\text{Estimated resistance to be measured}}{\text{Setting of MULTIPLY BY dial}} \quad \frac{500}{1} = 5{,}000$$

(2) Press the GA SENS .01 switch and note the direction of movement of the galvanometer pointer. If it moves to the right, increase the resistance total of the decaee dials until it does not move from zero when the GA SENS .01 switch is pressed. If the pointer moves to the left, decrease the resistance total of the decade dials. Repeat the above procedure, using the GA SENS .1 and then the GA SENS 1 Switches. The test procedure is complete when the GA SENS 1 switch is pressed and the pointer does not move in either direction. Under these conditions, the bridge circuit in the test set is said to be balanced.

c. Resistance Determination. The unknown resistance is equal to the sum of the decade dial settings multiplied by the setting of the MULTIPLY BY dial.

Example: If the bridge is balanced when the sum of the decade dial settings is 5,137 and the MULTIPLY BY dial is set at 1/10, the resistance connected across the line binding post is 5,137 x 1/10 or 513.7 ohms (decomal point moved one place to left). If the MULTIPLY BY dial is set at 1/100, move the decimal point two places to the left (51.37 ohms); for 1/1000, move the decimal point three places to the left (5.137 ohms). For 10/1, add one zero to the reading (51,370 ohms) and for 100/1, add two zeros (513,700 ohms).

15. Simple Loop Test for Locating Short

A simple method of locating a short is to determine the resistance of the short, from resistance measurements from each end of the shorted circuit, and use the resulting resistance value and the known resistance per mile or feet per ohm of the type of wire in the faulty circuit to compute the resistance from each end to the fault. When a fault has been identified as a short, have all equipment disconnected from both ends of the circuit and proceed as follows:

a. Determination of Loop Length (Test 1, fig. 5). If the length (distance from test point to far end) of the faulty loop is not known, compute it as follows:

(1) Measure the loop resistance of a good pair in the cable (par.14)

(2) Determine the loop length in miles by dividing the resistance per loop mile (par. 33) into the loop resistance. To compute the loop length in feet, multiply one-half the loop resistance by the number of feet per ohm of the wire.

b. Measurement from Test Point to Short (Test 2, fig. 5). Connect the shorted pair to line binding posts X1 and X2 and balance the bridge. Record the resistance measurement.

Note: This resistance is equal to the resistance of the short plus the resistance of the shorted circuit from the test point to the fault.

c. Equivalent Measurement from Far End (Test 3, fig. 5). Have a good cable pair connected to the shorted pair at the far end. Disconnect the shorted pair from the test set, connect the good pair to line binding posts X1 and X2, and measure the resistance of this circuit arrangement. Subtract the loop resistance (a(1) above) from the test 3 resistance measurement to obtain an equivalent resistance measurement from the far end of the shorted circuit.

Note: This resistance is equal to the resistance of the short plus the resistance of the shorted circuit from the far end to the fault.

d. Resistance of Short. Subtract the loop resistance (a(1) above) from the sum of the resistance measurement from each end of the

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SECTION IV

OPERATING INSTRUCTIONS

4-1. PRELIMINARY CHECKS.

4-2. To prevent damage to an indicator during test, check that the 30-position switch S2, the 8-position switch S7 and the 4-position switch S3 are turned to OFF before connecting the tester.

4-3. CABLE CONNECTIONS. The two black cables marked + and -, (with clips) and red and black insulators at the ends, are used for testing thermocouple-type meters, and for measuring the resistance of thermocouples and associated leads. The single cable with the connector fitting at the end is used when testing resistance-type meters.

4-4. CONTROLS.

4-5. Table II lists and describes controls used in operation.

TABLE II

CONTROLS AND FUNCTION

CONTROL	REFERENCE SYMBOL	FUNCTION
Interlock Switch	S1	Interlock switch which breaks power circuits when lid is closed.
Measurement Meter	M-1	Meter used as an indicator for standardizing measurements, and for checking the condition of the batteries.
Temperature Selector Switch	S2	Selects the various temperature calibration points on the scale of the 30-position switch. The outer portion of the dial is divided into three sections; the yellow section is used to test iron-constantan thermocouple thermometers, the green section is used to test chromel-alumel thermocouple thermometers and the red section is used to test copper-constantan thermocouple thermometers. The inner portion of the dial is divided into two sections; the left side is used to check indicators reading 0°C (32°F) at 90.38 ohms resistance and the right side is used to check indicators reading 0°C (32°F) at 50.00 ohms.
COARSE ADJUST INDICATOR	R51, R52	COARSE adjustment control for circuit of measurement meter M1. Provide proper power regulation as indicated on the standardizing meter for resistance-thermometer and thermocouple-thermometer test circuits.
FINE ADJUST INDICATOR	R53, R54	FINE adjustment control for circuit of measurement meter M1. Provides proper power regulation as indicated on the standardizing meter for resistance-thermometer and thermocouple-thermometer test circuits.
Thermocouple, Res. Thermometer LEAD RES. CHECK Switch	S7	An 8-position resistance and voltage selector switch can connect either 2 ± 0.05 ohms, 8 ± 0.05 ohms, or 22 ± 0.05 ohms in series with the thermocouple indicator under test. The switch without any series resistance provides means for testing the thermocouple indicator and its external circuit on aircraft. The switch provides means for selecting the lead resistance check circuit for measuring the resistance of thermocouples and associated leads.

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TABLE II. CONTROLS AND FUNCTIONS — (Continued)

CONTROL	REFERENCE SYMBOL	FUNCTION
		The switch also provides means for selecting either 12 or 24 volts, as required, for testing resistance-type thermometers.
LEAD RESISTANCE Selector Switch	S3	A 4-position switch controlling the switching of precision resistances in the tester as required for measuring 2, 8 and 22 ohm thermocouple lead circuits.
ERROR IN OHMS Control	R55, R56	A resistance control employed for balancing the tester bridge circuit when measuring thermocouple lead resistance (balance noted on measurement meter M-1) and for registering the error existing in the particular lead circuit being measured. Measures over range of -1 ohm to + 1 ohm.
Lead Resistance Safety Switch	S9	A safety switch employed to protect measurement meter M-1 from being damaged due to severe unbalances when measuring thermocouple lead resistance. When near balance the switch circuit is closed which shorts out circuit series protective resistance.
LEFT AND SINGLE-RIGHT Switch	S8	A 2-position shorting-type selector switch. When set to LEFT AND SINGLE position, resistance thermometer indicators of the single-engine type can be tested, and the left-hand scale of dual-type indicators. When set to the right position, right-hand scale of dual-type indicators can be tested.
ZERO ADJUST		Adjusts needle on measurement meter to zero.

4-6. OPERATION. (See figure 4-1).

4-7. An indicator may be checked in the airplane or on the bench.

4-8. AIRPLANE TEST.

a. Place the tester near the instrument to be tested, on a fairly level and firm surface and open the lid of the instrument.

b. Remove the glass thermometer from the lid of the instrument and hang it near the indicator being tested, so that it will reach the temperature of the instrument.

c. Determine which type of thermocouple is used with the indicator.

d. Disconnect the + side of the thermocouple at the indicator, and clip the + (red insulator) alligator clip from the tester to the + terminal of the indicator. Connect the side - side (black insulator) to the disconnected thermocouple lead.

e. Turn the ZERO ADJUST of the indicator so that it reads the same temperature as the glass thermometer.

START HERE

NOTE

This is what is known as the Cold Junction Temperature, and must be subtracted from the subsequent test readings. The tester applies millivoltage based on zero degrees, (chromel-alumel thermocouples), therefore the tester will make the indicator read to high by the amount the Cold Junction Temperature is above 0°C (32°F). For copper-constantan thermocouples 20°C (68°F) is the reference temperature.

f. Set the pointer of the 30-position switch to the starting temperature on the scale corresponding to the thermocouple of the indicator and the starting point of the Indicator Scale. (Some scales start at 200 degrees instead of zero).

g. Turn the ZERO ADJUST of the meter M-1 on the panel of the tester, until the pointer is directly over the line at the zero (left) end of the scale.

h. Turn the 8-position switch to AIRPLANE TEST 0 ohm.

i. Adjust the COARSE and FINE rheostats until the pointer of the meter M-1 on the tester is over the red line at the right end of its scale.

j. The indicator should read the same temperature as that on the tester, switch 2, plus the Cold Junction Temperature.

k. Continue for all the following positions of the Indicator Scale. Make sure that the pointer of the meter M-1 on the tester is over the red line at each position. The indicator must agree with the tester plus the Cold Junction Temperature within the tolerance specified for that indicator.

START HERE

4-9. BENCH TEST.

a. The procedure in this test is the same as the panel test except that the meter is off the panel and disconnected from the thermocouple. Check the Cold Junction Temperature with the glass thermometer and adjust the indicator to this value.

b. Connect the clips from the tester directly to the meter terminals, red to +, black to -.

c. Turn the 8-position switch to the value of 2 ohms, 8 ohms, or 22 ohms, which equals the resistance of the thermocouple used with that particular meter.

d. Proceed with the test as described under paragraph 4-8. c, f, i, j and k.

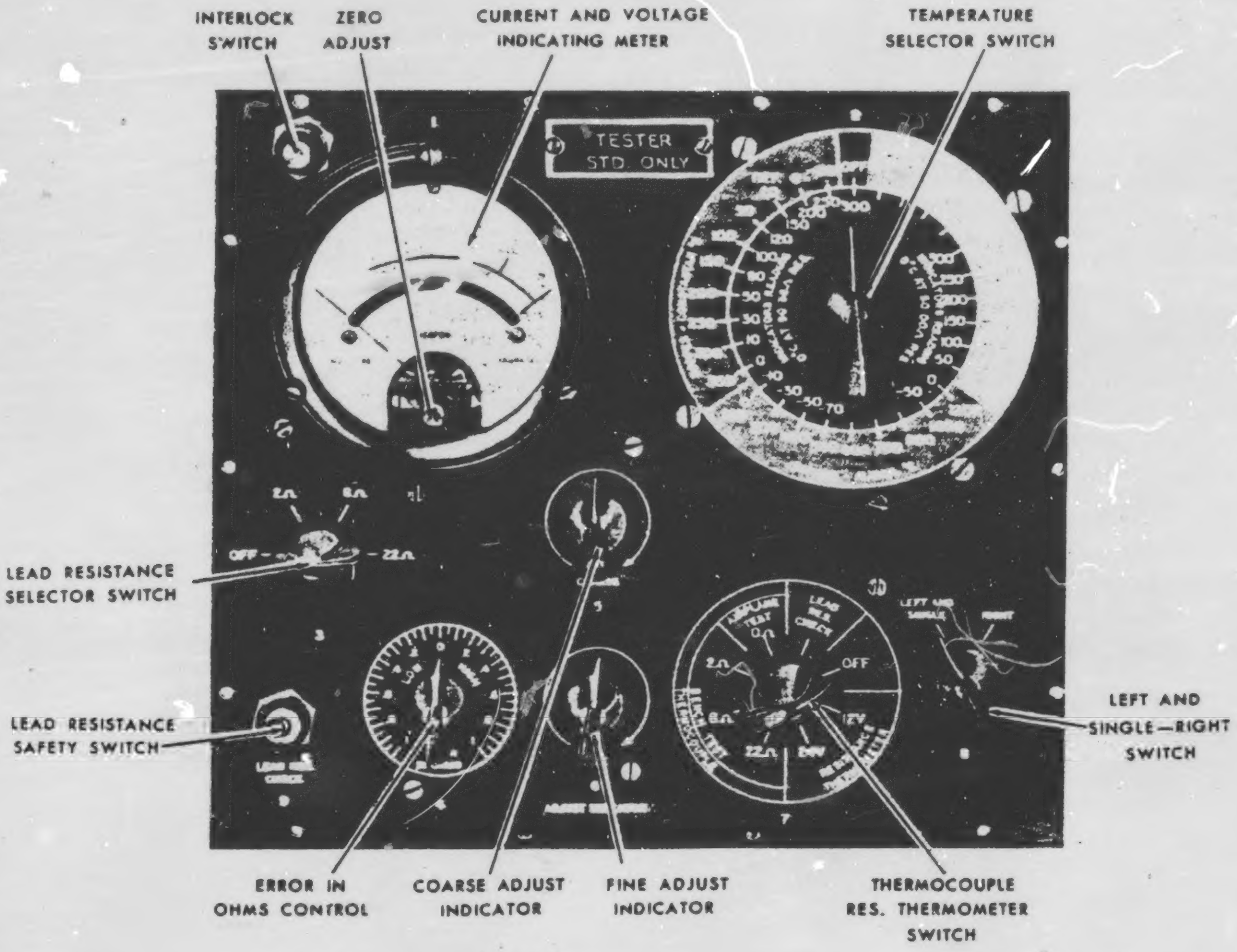

INTERLOCK SWITCH
ZERO ADJUST
CURRENT AND VOLTAGE INDICATING METER
TEMPERATURE SELECTOR SWITCH
TESTER STD. ONLY
OFF
2Ω
8Ω
22Ω
LEAD RESISTANCE SELECTOR SWITCH
LEAD RESISTANCE SAFETY SWITCH
LEAD RES. CHECK
AIRPLANE TEST
LEAD RES. CHECK
12V
LEFT AND SINGLE—RIGHT SWITCH
ERROR IN OHMS CONTROL
COARSE ADJUST INDICATOR
FINE ADJUST INDICATOR
THERMOCOUPLE RES. THERMOMETER SWITCH

Figure 1.

PROGRAMMED TEXT
3ABR32531-PT-205
3ABR32632B-PT-305

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

FUEL FLOW INDICATING SYSTEM

9 January 1978

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

775

FOREWORD

This programmed text was prepared for use in the 3ABR32531 and 3ABR32632B instructional systems and was validated using 31 students enrolled in the 3ABR32531 and 3ABR32632B courses. At least 90 percent of the students achieved the objective as stated. The average time required to complete this text is 52 minutes.

OBJECTIVE

Without references, identify facts pertaining to the purpose, operation, and/or characteristics of a fuel flow indicating system with an accuracy of at least 80%.

INSTRUCTIONS

This programmed text presents information in small steps called "FRAMES." After reading the information in each frame, you are asked to actively respond on the response sheet provided. Check the accuracy of your response with the correct answer(s) that are given after the following frame. If you make an incorrect response, study the frame again before going on to the next frame; DO NOT HURRY! DO NOT WRITE IN THIS PT!

Supersedes 3ABR32531-PT-606, 3ABR42230-PT-310, 1 November 1971.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 200; TTVSA - 1

Frame 1

The fuel flow system measures the rate of fuel flow to the aircraft engines in pounds per hour (PPH). Although the fuel flow system is not absolutely essential for safe aircraft operation, it is one that is extremely important in flight planning. The fuel flow system aids the pilot in many ways, but one of the most important ways is to aid him in establishing cruise control. You can see that if the pilot knows exactly how much fuel is being consumed by each engine, he can determine whether or not he has sufficient fuel to reach his destination. The fuel flow system also indicates an engine malfunction to the pilot. This engine malfunction becomes apparent when the rate of fuel flow is either too high or too low for a given throttle setting. If the amount of fuel used per hour is too low, the pilot knows that his engine is not producing normal power. On the other hand, if the amount of fuel per hour is too high, the pilot knows that the engine is using too much fuel and that he must monitor his total fuel more closely.

Circle the letter of the correct answer(s).

1. The purpose of the fuel flow indicating system is to measure fuel flow in

   a. gallons per minute.
   b. gallons per hour.
   c. pounds per minute.
   d. pounds per hour.

777
Frame 2

For a single engine aircraft, the components in the fuel flow system consist of a fuel flow transmitter (figure 1) and an individual indicator (figure 2).

The fuel flow indicating system for a multi-engine airplane requires one additional component, a total fuel flow indicator (figure 3). Each engine has a transmitter and an individual indicator to show how much fuel is being consumed by each individual engine. The system has a totalizer indicator so that the pilot can look at this one instrument and tell how much of the total fuel is being consumed each hour.

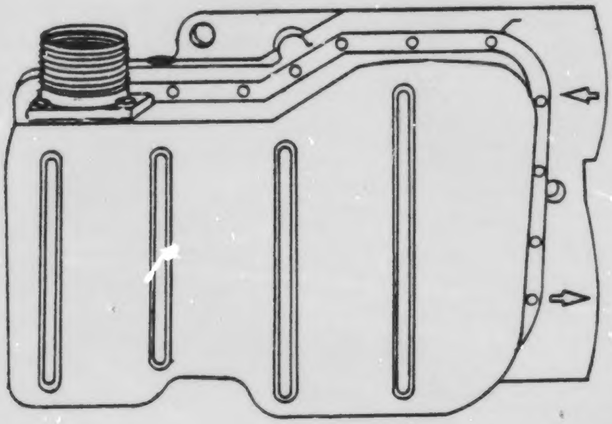


Figure 1.

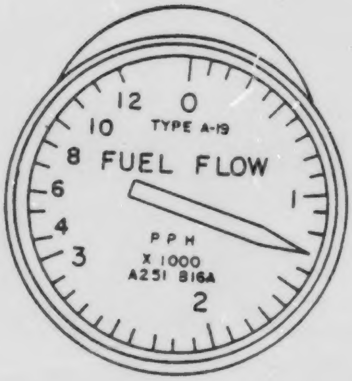

12
0
10
TYPE A-19
8
FUEL FLOW
6
1
4
3
PPH
X 1000
A251 816A
2

Figure 2.

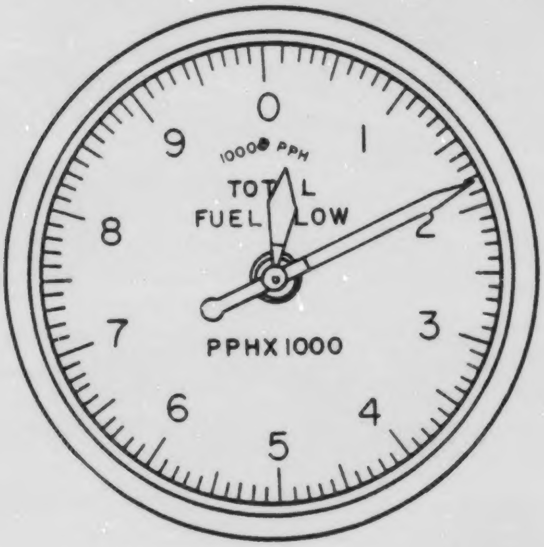

0
9
1000 PPH
1
TOTAL
FUEL FLOW
8
2
7
3
PPHX1000
6
4
5

Figure 3.

Refer to figures 1 through 3 and circle the letter of the correct response to the following statement.

1. An eight engine aircraft would have eight transmitters and

   a. two individual indicators, and one totalizer indicator.
   b. four individual indicators, and two totalizer indicators.
   c. six individual indicators, and two totalizer indicators.
   d. eight individual indicators, and one totalizer indicator.

Answer to Frame 1: 1. d

Frame 3

The individual fuel flow indicator (figure 2) indicates a rate of fuel flow from 0 to 12,000 pounds per hour (PPH). Each digit (1, 2, etc) is multiplied by 1,000 pounds per hour of fuel flow. From 0 to 3 there are ten (10) increments (marks) from one digit to another. Therefore, these increments equal 100 PPH of fuel flow. From 3 to 12 each mark or digit equals 1,000 PPH.

Circle the letter of the correct responses to the following statements.

1. The individual indicator will indicate fuel flow from

   a. 0 - 120 pounds per hour.
   b. 0 - 120 pounds per minute.
   c. 0 - 1,000 pounds per hour.
   d. 0 - 12,000 pounds per hour.

2. The individual indicator in figure 2 indicates the rate of fuel flow is

   a. 1,300 PPH.
   b. 10,300 PPH.
   c. 100,300 PPH

Answer to Frame 2: 1. d

Frame 4

The totalizer indicator has two pointers. The long narrow pointer is read exactly like the pointer of the individual fuel flow indicator, previously explained. The short wide pointer indicates a fuel flow rate of 10,000 PPH from one digit to the next.

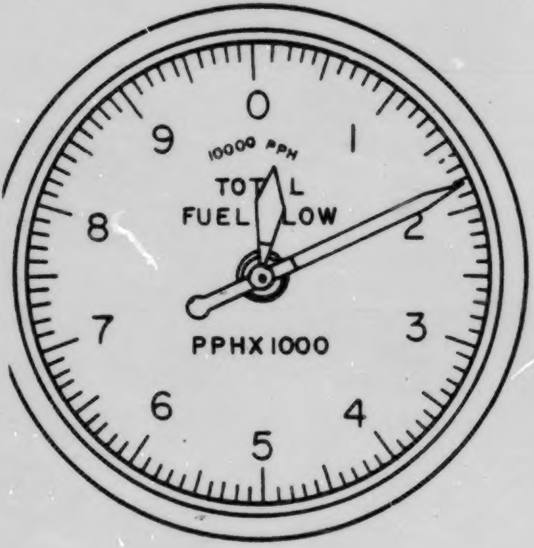

0
1
2
3
4
5
6
7
8
9
10000 PPH
TOT L
FUEL LOW
PPHX1000

Figure 4.

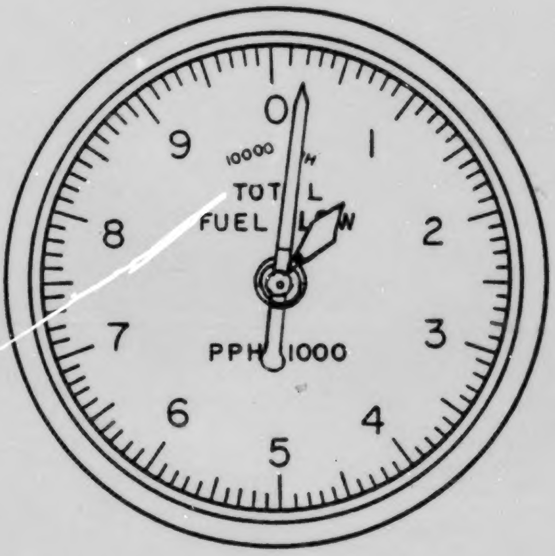

0
1
2
3
4
5
6
7
8
9
10000
TOT L
FUEL L W
PPH 1000

Figure 5.

Refer to figures 4 and 5 and circle the letter of the correct responses to the following statements.

1. The totalizer indicator (figure 4) indicates a fuel flow rate of

   a. 1,825 PPH.
   b. 10,825 PPH.
   c. 20,825 PPH.

2. The totalizer indicator (figure 5) indicates a fuel flow rate of

   a. 1,200 PPH.
   b. 10,200 PPH.
   c. 21,000 PPH.

Answers to Frame 3: 1. d 2. a

Frame 5

The fuel flow transmitter has two sections. These are the fuel measuring section "2" and the electrical section "1." Figure 6 shows the two sections. These sections are separated by a leak proof seal "H" which consists of a metal plate between fuel section and electrical section. The transmitter changes the rate of fuel flow to an electrical signal. Figure 6 also shows some of the units of the transmitter that will be discussed in later frames.

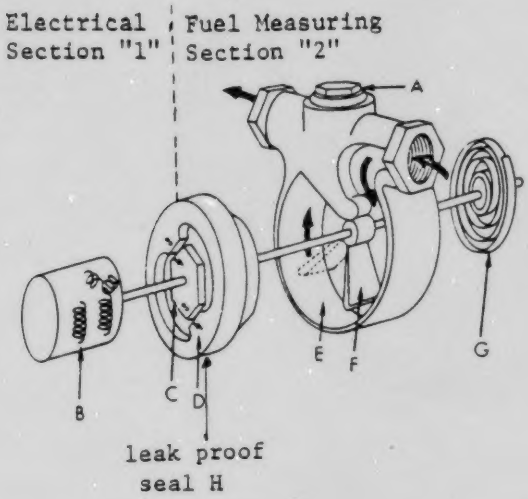


Figure 6.

Circle the letter of the correct response to the following statement.

1. The fuel flow transmitter changes rate of fuel flow to

    a. an electrical signal.
    b. a mechanical signal.
    c. a hydraulic signal.

Answers to Frame 4: 1. a 2. b

Frame 6

Fuel enters the transmitter at the fuel inlet (Port A). (See figure 7.) The arrows show the path of flow through the metering chamber "E." As the fuel flows through the chamber, it moves the metering vane "F." The shaft that has the vane mounted on it is connected to the calibrated spring "G." This spring works in opposition to the vane movement and helps to dampen the movement of the vane. The spring returns the vane to NO FLOW position when the fuel flow stops.

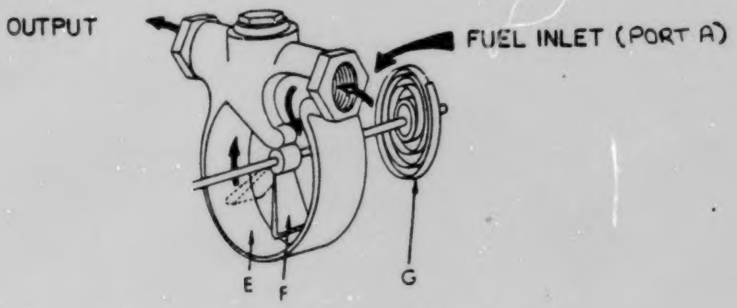


Figure 7.

Circle the letter of the correct responses to the following statements.

1. The calibrated spring

   a. aids fuel flow.
   b. aids vane movement.
   c. opposes the fuel flow.
   d. opposes vane movement.

2. When fuel flow is shut off, the calibrated spring moves the vane to the

   a. no flow position.
   b. full flow position.
   c. mid range flow position.

Answer to Frame 5: 1. a

Frame 7

The metering chamber of the transmitter is a spiral chamber. You will notice in figure 8 that this chamber is not concentric (distance between the vane and spiral chamber varies as the vane moves). This provides for a higher indication of fuel flow with less vane movement at the high range of the indicator. As an example, the vane moves through the first 130° to provide a fuel flow indication of 0 to 3,000 pounds per hour, and the vane moves through the last 48° to provide a fuel flow indication of 3,000 to 12,000 pounds per hour.

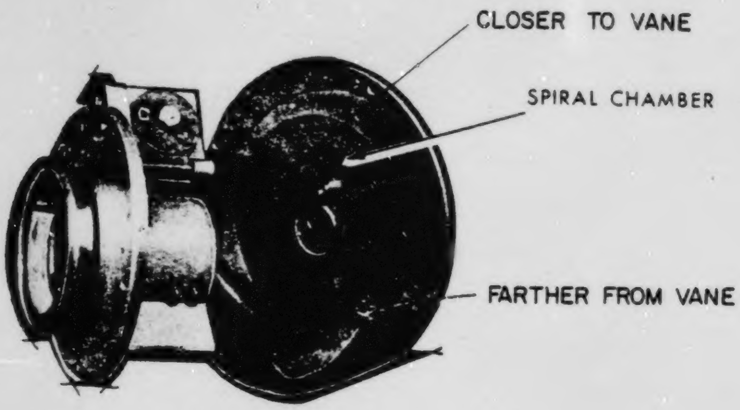


Figure 8.

Circle the letter of the correct responses to the following statements.

1. When the vane moves through the first 130° of the spiral chamber, the fuel flow indication will be

   a. 0 to 30 pounds per hour.
   b. 0 to 300 pounds per hour.
   c. 0 to 3000 pounds per hour.
   d. 3,000 to 12,000 pounds per hour.

2. The last 48° of vane movement will provide a fuel flow indication of

   a. 0 - 3,000 pounds per hour.
   b. 0 - 30,000 pounds per hour.
   c. 3,000 to 12,000 pounds per hour.
   d. 3,000 to 120,000 pounds per hour.

Answers to Frame 6: 1. d 2. a

As a safety precaution, the transmitter is equipped with a bypass relief valve. (See figure 9.) The valve is of the spring type and will open any time the rate of fuel flow exceeds the flow limits of the transmitter. This valve allows fuel to bypass the measuring section and reach the engine if the movable vane becomes stuck or there is a surge in fuel pump pressure.

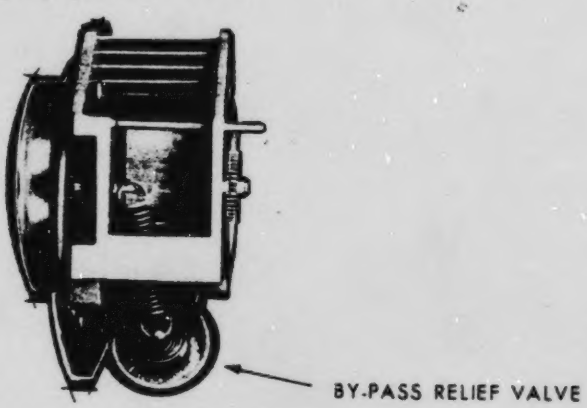


Figure 9.

Circle the letter of the correct response to the following statement.

1. The purpose of the relief valve is to

   a. maintain a constant fuel pressure.
   b. relieve low fuel pressure.
   c. relieve sudden surges of fuel pressure.
   d. stay open at all times during operation.

Answers to Frame 7: 1. c 2. c

785

Frame 9

Attached to one end of the vane shaft is a ring magnet. A ring magnet is shown in figure 10A. The movable vane, calibrated spring, and ring magnet are all sealed within the fuel metering chamber of the measuring section in figure 10A. The vapor proof seal placed over the ring magnet keeps fuel from the electrical section of the transmitter, figure 10B. The vapor proof seal also contains the mount for the pinion gear. Attached to this pinion gear is a bar magnet in figure 10B and 10C. This arrangement is called magnetic coupling. Even though a thin metal wall separates the two magnets, the bar magnet will align itself with the magnetic field of the ring magnet due to the magnetic attraction between the two. When the ring magnet is rotated by the movable vane shaft, the bar magnet is repositioned and turns the pinion gear.

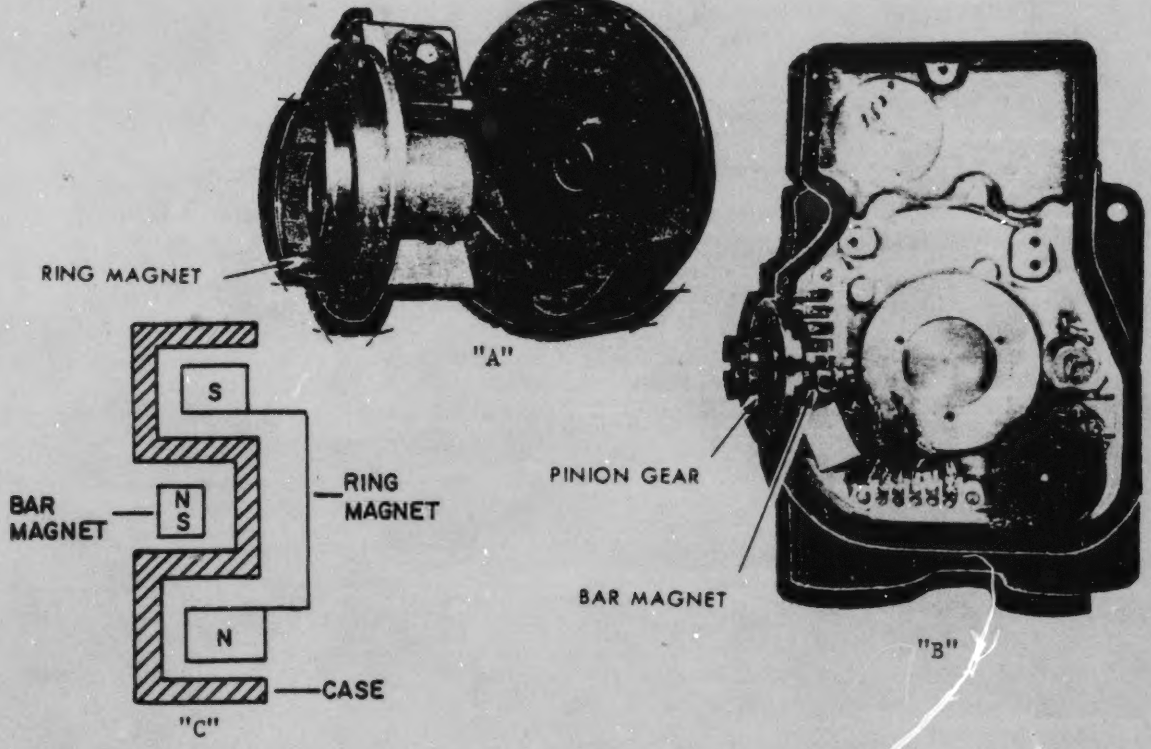


Figure 10.

896

Refer to figure 10 and circle the letter of the correct responses to the following statements.

1. The purpose of the magnetic coupling is to transmit motion from the fuel metering chamber to the electrical section by

   a. mechanical linkage.
   b. electrical transformer action.
   c. attraction of like magnetic poles.
   d. magnetic attraction between ring and bar magnets.

2. The movable vane, ring magnet, bar magnet, and the pinion gear make up the magnetic coupling and

   a. turns the vane when fuel flow changes.
   b. opens the relief valve when fuel flow changes.
   c. drives the pinion gear when fuel flow changes.
   d. drives the pinion gear when fuel flow is constant.

Answer to Frame 8: 1. c

Frame 10

Figure 11 below shows an open view of the electrical section of a multisynchro fuel flow transmitter commonly used on multi-engine aircraft. This open view shows all of the units in the transmitter except the measuring section (fuel section). The electrical section also includes the unit necessary to operate a totalizer indicator. The units shown in figure 11 include an adjustable synchro transformer (A), movable vane pinion gear (B), sector gear (C), linear synchro with pinion gear (D), transmitter synchro (E), and an autotransformer (F).

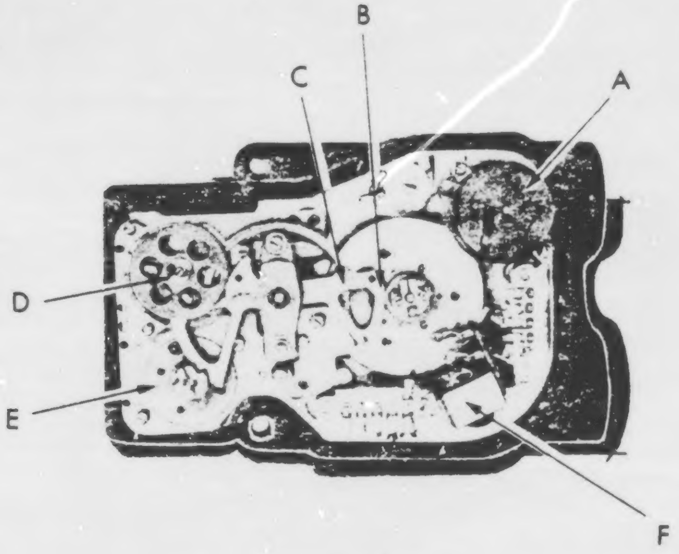


Figure 11.

Refer to figure 11 and circle the letter of the correct response to the following statements.

1. The sector gear

   a. drives the movable vane pinion gear.
   b. is driven by the movable vane pinion gear.
   c. is driven by the synchro pinion gears.

Answers to Frame 9: 1. d 2. c

The vane movement of the transmitter is transferred through the magnetic coupling to the vane pinion gear. The three segmented sector gear "C" is meshed with the pinion gear at point (B). The other two segments of the sector gear mesh with the gears that drive the rotor of the transmitter synchro (E) and the rotor of the linear synchro (D). When the vane moves, the pinion gear moves, driving both synchro rotors by movement of the sector gear. Refer to figure 11.

Refer to figure 11 and circle the letter of the correct responses to the following statements.

1. The rotors of the transmitter synchro and linear synchro are moved by

    a. magnetic attraction.
    b. magnetic repulsion.
    c. the movement of the sector gear.

2. The pinion gear is moved by

    a. a mechanical connection.
    b. magnetic attraction.
    c. magnetic repulsion.

Answer to Frame 10: 1. b

789

Frame 12

The transmitter synchro consists of a 3-phase wye-connected stator with a two pole electromagnetic rotor. This is the same type synchro that has been studied earlier in the synchro pressure indicating system programmed text. See figure 12 for a schematic of the transmitter synchro. This synchro is used to transmit the fuel flow signal to the individual synchro indicator. Notice that the rotors of the transmitter and indicator are connected to a 26V AC 400 Hz single-phase power source. The diagram also shows that the rotor is mechanically linked to the vane. As the vane is moved, the rotor will move and induce a voltage into the stators of the transmitter synchro. This in turn will send a signal to the stators of the individual indicator. The rotor of the indicator will be repositioned and in turn reposition the indicator pointer.

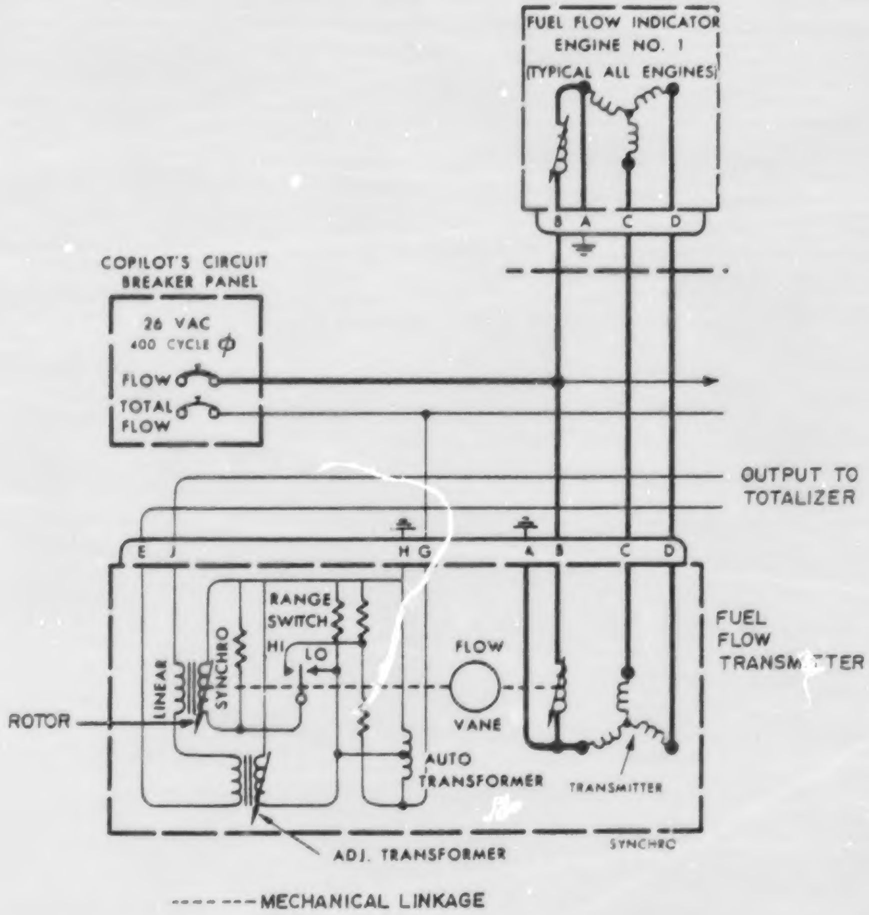

FUEL FLOW INDICATOR
ENGINE NO. 1
(TYPICAL ALL ENGINES)
B
A
C
D
COPILOT'S CIRCUIT BREAKER PANEL
26 VAC
400 CYCLE ɸ
FLOW
TOTAL FLOW
OUTPUT TO TOTALIZER
E
J
H
G
A
B
C
D
RANGE SWITCH
HI
LO
LINEAR
SYNCHRO
FLOW
VANE
ROTOR
AUTO TRANSFORMER
TRANSMITTER
SYNCHRO
FUEL FLOW TRANSMITTER
ADJ. TRANSFORMER
------MECHANICAL LINKAGE

Figure 12.

Refer to figure 12 and circle the letter of the correct responses to the following statements.

1. The 26V AC 400-Hz single-phase power is
   - a. used to move the vane.
   - b. connected to the rotor of the transmitter synchro.
   - c. connected to the stator of the transmitter synchro.
   - d. connected to the indicator and transmitter rotors.

2. When the vane moves, a voltage is induced in the stator of the transmitter synchro and sends a signal to the
   - a. synchro of the individual indicator.
   - b. rotor of the transmitter synchro.
   - c. vane of the transmitter synchro.

Answers to Frame 11: 1. c 2. b

791

Frame 13

The linear synchro in the transmitter produces the signal that operates the totalizer indicator. The rotor of the linear synchro is energized with electrical power from the aircraft power supply via the auto transformer. Only two leads of the stator are connected in the circuit. A signal ratio of 1 volt per thousand pounds of fuel flow must be maintained within the linear synchro for proper indications to be displayed. Figure 12 shows the linear synchro in a fuel flow transmitter.

Circle the letter of the correct responses to the following statements.

1. The totalizer indicator operates on the signal that is

   a. produced by the synchro transmitter.
   b. supplied by the aircraft AC power system.
   c. produced by the linear synchro.

2. The stator of the linear synchro has

   a. all three leads connected.
   b. two leads connected.
   c. two leads and the rotor connected.
   d. all three leads and the rotor connected.

Answers to Frame 12: 1. d 2. a

Frame 14

Since only a small amount of rotor movement takes place when the rate of fuel flow exceeds 3,000 pounds per hour, a means of stepping up the linear synchro output is necessary. This is done by a switch that is actuated by a two lobed cam attached to the rotor shaft of the individual synchro assembly. This switch is called the Hi-Lo switch or the range switch. When the rate of flow exceeds 3,000 pounds per hour, the switch is repositioned from the low position to the high position by the mechanical linkage (dotted line from the rotor shaft of the individual synchro) and allows a higher voltage to be applied to the rotor of the linear synchro. This in turn will send a stronger signal to the totalizer indicator causing it to read higher. See figure 13 for switch in low position and fig. 14 for switch in high position.

Circle the letter of the correct responses to the following statements.

1. The Hi-Lo switch is positioned to the Hi or Lo position by the movement of the

   a. movable vane.
   b. rotor shaft of the linear synchro.
   c. rotor shaft of the individual synchro.

2. When the Hi-Lo switch is moved to the Hi position

   a. a stronger signal is sent to the totalizer indicator.
   b. a weaker signal is sent to the totalizer indicator.
   c. there is no change in the signal sent to the totalizer indicator.

Answers to Frame 13: 1. c 2. b

Frame 15

The autotransformer supplies the low excitation voltage to the linear synchro rotor. The transformer is energized by 26V AC from the aircraft power supply. See the heavy black lines in figure 13. When the range switch is positioned to the right, a low excitation voltage will be supplied to the linear synchro rotor from the center tap of the transformer. This low voltage is used for rates of flow from 0 to 3,000 PPH. As the rate of flow exceeds 3,000 PPH, the switch moves to the left, figure 14, and a higher voltage is applied to the rotor. The switching of the rotor excitation voltages is necessary to maintain the 1 volt per 1,000 pound per hour ratio within the linear synchro.

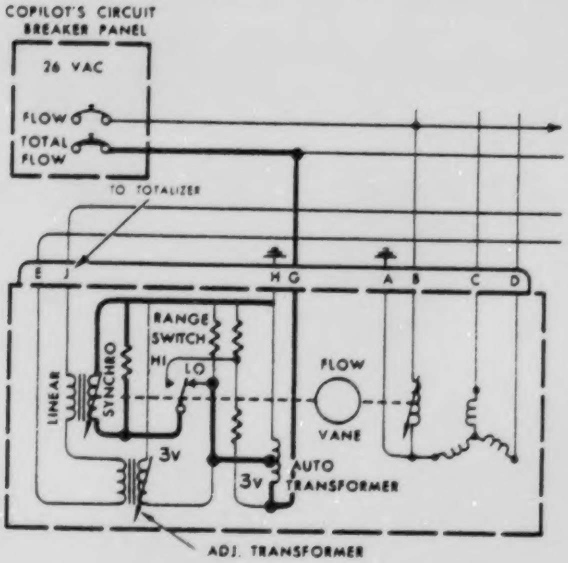

COPILOT'S CIRCUIT BREAKER PANEL
26 VAC
FLOW
TOTAL FLOW
TO TOTALIZER
E
J
H
G
A
B
C
D
RANGE SWITCH
HI
LO
LINEAR
SYNCHRO
FLOW
VANE
3v
3v
AUTO TRANSFORMER
ADJ. TRANSFORMER

Figure 13.

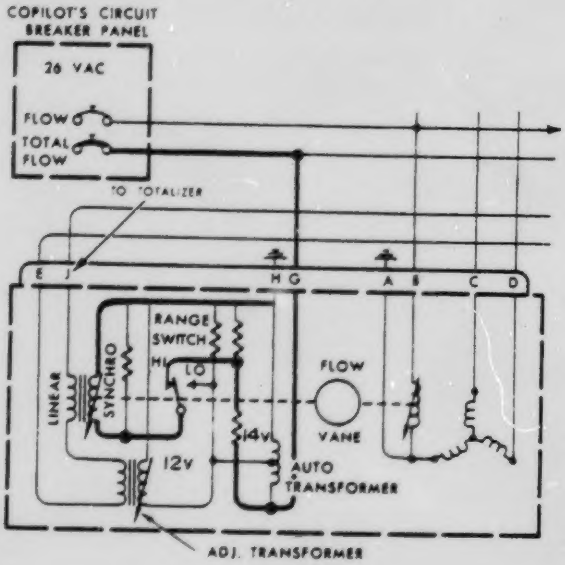

COPILOT'S CIRCUIT BREAKER PANEL
26 VAC
FLOW
TOTAL FLOW
TO TOTALIZER
E
J
H
G
A
B
C
D
RANGE SWITCH
HI
LO
LINEAR
SYNCHRO
FLOW
VANE
14v
12v
AUTO TRANSFORMER
ADJ. TRANSFORMER

Figure 14.

Circle the letter of the correct responses to the following statements.

1. The autotransformer supplies low excitation voltage, via the range switch, to the rotor of the

   a. individual synchro.
   b. adjustable transformer.
   c. linear synchro.

2. The autotransformer along with the Hi-Lo switch maintains 1 volt per 1,000 pounds per hour ratio within the

   a. linear synchro.
   b. autotransformer.
   c. adjustable transformer.
   d. range switch

81

Answers to Frame 14: 1. c 2. a

The adjustable transformer is a synchro unit used only as a variable transformer in the circuit. When this synchro is installed at the factory, the rotor is adjusted and locked in position to provide a zero signal output from the linear synchro when the transmitter is at a NO FLOW PPH condition. Refer to figure 13. Notice that the secondary of the adjustable transformer is in series with the stator of the linear synchro. Since only two leads of the stator are connected in the circuit, only two leads (E&J) appear at the electrical connector plug.

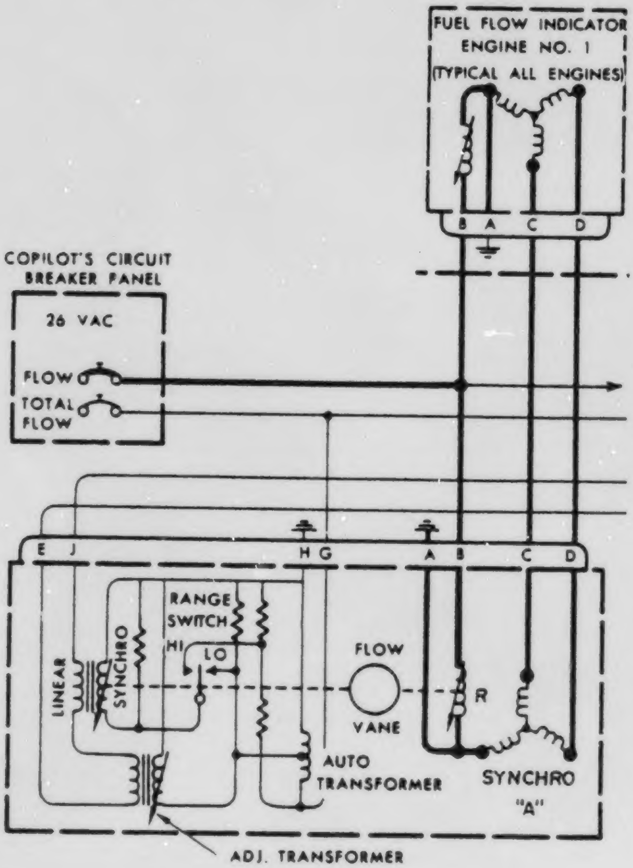
Circle the letter of the correct responses to the following statements.

1. The rotor of the adjustable transformer
    - a. is locked.
    - b. turns with the stator.
    - c. turns opposite the stator movement.
    - d. is locked to use as variable resistor.
2. The adjustable transformer provides a zero signal output from the
    - a. autotransformer when the transmitter is at a NO FLOW condition.
    - b. individual synchro when the transmitter is at a NO FLOW condition.
    - c. linear synchro when the transmitter is at a NO FLOW condition.
    - d. linear synchro when the transmitter is at a FULL FLOW condition.

Answers to Frame 15: 1. c . 2. a

Frame 17

The individual indicator synchro is connected electrically to the synchro "A" in the transmitter. There is a transmitter and indicator for each engine, on multi-engine aircraft, see figure 15. This figure shows a single engine schematic that is typical of ALL engines. As the movable vane is displaced by fuel, the rotor "R" of the synchro transmitter is moved. This sends an electrical signal to the individual indicator stators which cause the magnetized rotor in the indicator to align with the transmitter rotor. The rotor of the indicator synchro turns the pointer, indicating the amount of fuel flow in pounds per hour, see figure 16. The rotor of the individual synchro is a two pole electromagnet similar to the one in the transmitter synchro.


FUEL FLOW INDICATOR
ENGINE NO. 1
(TYPICAL ALL ENGINES)
B A C D
COPILOT'S CIRCUIT BREAKER PANEL
26 VAC
FLOW
TOTAL FLOW
E J
H G
A B C D
RANGE SWITCH
HI
LO
LINEAR
SYNCHRO
FLOW
VANE
R
AUTO TRANSFORMER
SYNCHRO "A"
ADJ. TRANSFORMER

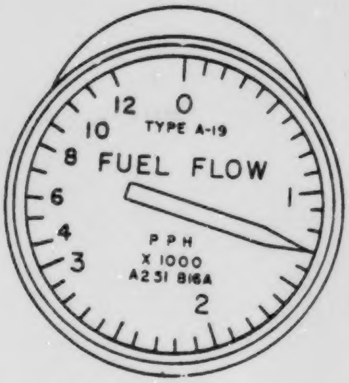

12
0
10
TYPE A-19
8
FUEL FLOW
6
1
4
3
PPH
X 1000
A2S1 816A
2

Figure 16.

Circle the letter of the correct responses to the following statements.

1. An electrical signal is sent to the individual indicator(s) by the movement of the

   a. transmitter synchro rotor.
   b. adjustable transformer.
   c. linear synchro rotor.
   d. E & J leads.

2. The rotor of the individual indicator is a

   a. two-pole permanent magnet.
   b. two-pole electromagnet.
   c. four-pole permanent magnet.
   d. four-pole electromagnet.

3. The individual indicator in figure 16 is indicating a fuel flow of

   a. 13,000 PPH.
   b. 10,300 PPH.
   c. 1,300 PPH.

Answers to Frame 16: 1. a 2. c

Frame 18

As previously stated, there is one transmitter and one individual indicator for each engine. If there are four engines, there are four transmitters; four linear synchros (E&J) connected in series to indicate total fuel for all four individual indicators. See figure 17 below. Now we are going to add a totalizer indicator to the system. The purpose of this totalizer indicator is to indicate the total amount of fuel flow for all engines in pounds per hour. The total fuel flow indicator consists of two synchro units, a two-phase motor-generator unit, an amplifier and a gear train. Two pointers on the indicator indicate the total fuel flow in pounds per hour for all engines. The range of this indicator is from 0 to 100,000 pounds per hour. Figure 17 shows the electrical schematic of a four engine aircraft fuel flow system. Notice that the linear synchros of the four fuel flow transmitters are connected in series, and the electrical signal that represents total fuel flow is applied to pins A and E of a total fuel flow indicator.

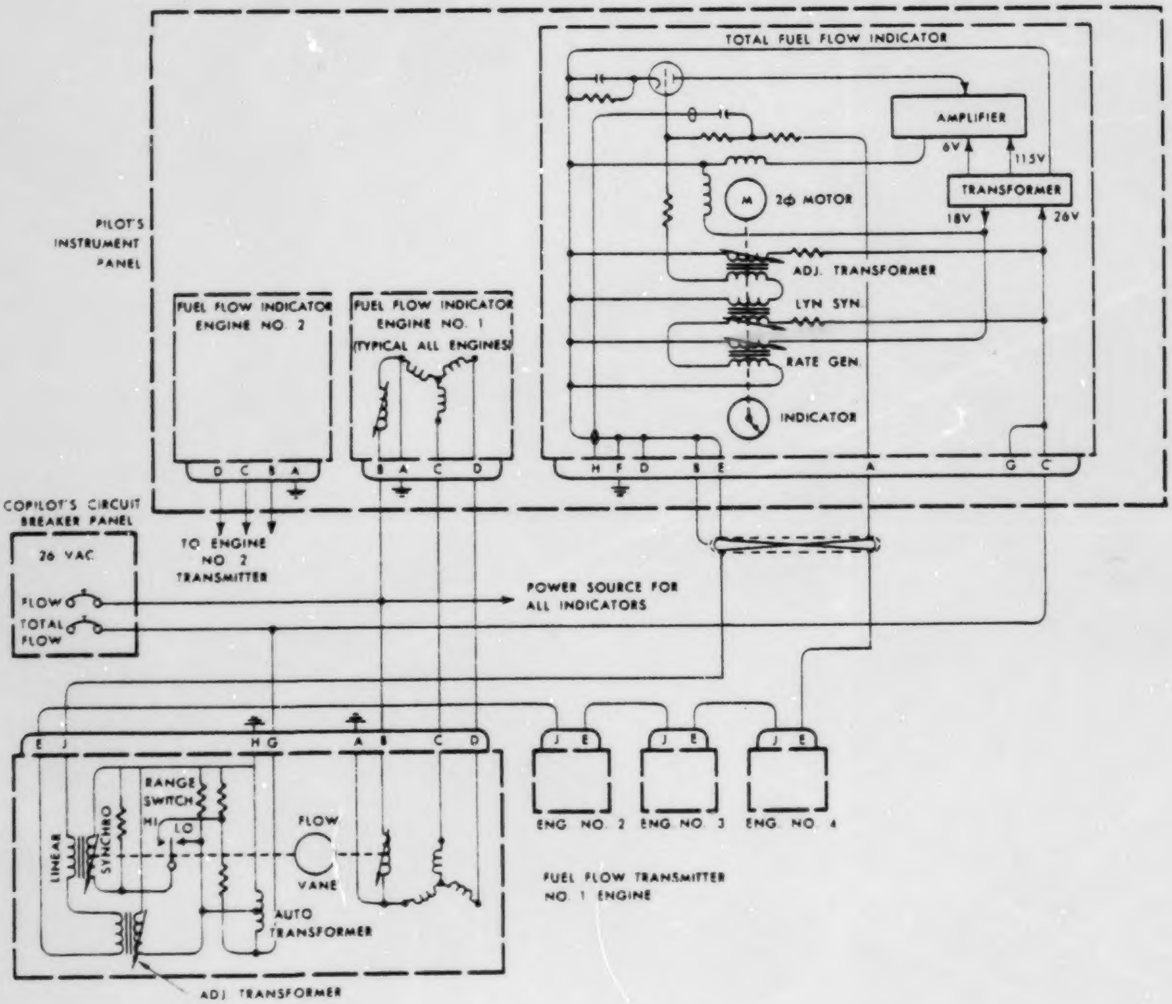

TOTAL FUEL FLOW INDICATOR
AMPLIFIER
6V
115V
TRANSFORMER
18V
26V
M
2φ MOTOR
ADJ. TRANSFORMER
LYN SYN
RATE GEN.
INDICATOR
H F D B E A G C
PILOT'S INSTRUMENT PANEL
FUEL FLOW INDICATOR ENGINE NO. 2
D C B A
FUEL FLOW INDICATOR ENGINE NO. 1 (TYPICAL ALL ENGINES)
B A C D
COPILOT'S CIRCUIT BREAKER PANEL
26 VAC
FLOW
TOTAL FLOW
TO ENGINE NO 2 TRANSMITTER
POWER SOURCE FOR ALL INDICATORS
E J H G A B C D
J E
J E
J E
ENG NO 2
ENG NO 3
ENG NO 4
LINEAR
SYNCHRO
RANGE SWITCH
HI
LO
FLOW
VANE
AUTO TRANSFORMER
ADJ TRANSFORMER
FUEL FLOW TRANSMITTER NO. 1 ENGINE

Figure 17.

Circle the letter of the correct responses to the following statements.

1. The purpose of the totalizer indicator is to indicate the total fuel flow of all engines in

    a. gallons per minute.
    b. gallons per hour.
    c. pounds per minute.
    d. pounds per hour.

2. The linear synchros in the fuel flow transmitters of a four engine aircraft

    a. are connected in series.
    b. are connected in parallel.
    c. operate separate totalizers.
    d. operate the individual indicators.

Answers to Frame 17: 1. a 2. b 3. c

Frame 19

The totalizer indicator contains a signal amplifier. This amplifier receives and amplifies the signal from the linear synchros in the engine fuel flow transmitters. The sum of the signal received from the transmitter are applied to the grid of VI, Triode Amplifier Tube, figure 18. The amplified signal is used to run a two-phase motor in the totalizer (totalizer fuel flow indicator).

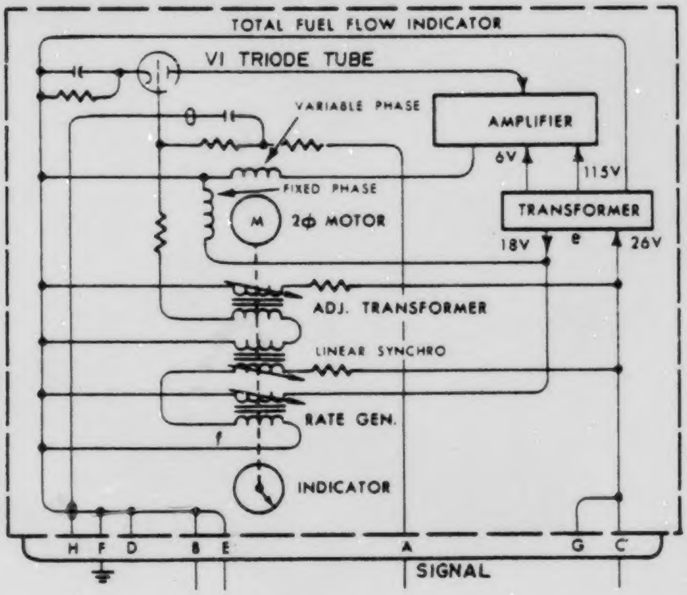

TOTAL FUEL FLOW INDICATOR
VI TRIODE TUBE
VARIABLE PHASE
AMPLIFIER
6V
115V
FIXED PHASE
M
2Φ MOTOR
TRANSFORMER
18V
e
26V
ADJ. TRANSFORMER
LINEAR SYNCHRO
RATE GEN.
f
INDICATOR
H
F
D
B
E
A
G
C
SIGNAL

Figure 18.

Circle the letter of the correct response to the following statement.

1. The amplifier is used to amplify the signal from the

   a. autotransformer.
   b. adjustable transformer.
   c. linear synchro in the transmitters.
   d. individual synchro in the transmitters.

Answers to Frame 18: 1. d 2. a

The totalizer motor-generator unit consists of a two-phase induction motor and a rate generator. The fixed phase of the motor receives its reference voltage from the transformer in the indicator. The variable phase receives its voltage from the output of the signal amplifier, see figure 18. The rotor of the rate generator receives its reference voltage from the transformer. The variable phase output is used as a signal dampening feedback signal to the amplifier. This prevents the motor from overtraveling, which would cause an oscillation movement of the pointer on the dial.

Circle the letter of the correct responses to the following statements.

1. The variable phase of the two-phase motor receives its voltage from the

   a. adjustable transformer.
   b. amplifier.
   c. transformer.
   d. linear synchro.

2. The fixed phase of the motor has

   a. 6 volts applied to it.
   b. 18 volts applied to it.
   c. 26 volts applied to it.
   d. 115 volts applied to it.

Answer to Frame 19: 1. c

Frame 21

The totalizer indicator transformer is a multi-tap transformer which supplies the necessary voltages for indicator operation. The transformer receives its primary voltage from the aircraft power source (26V AC) C terminal. Output voltages of 115, 18, and 6 volts AC are available from the transformer. The 115V AC output is supplied to the plate of the amplifier tube. The 6V AC output of the transformer is supplied to the heater of the amplifier tube. The 18V AC output is supplied to the fixed phase of the induction motor and the rotor of the rate generator, see figure 19.

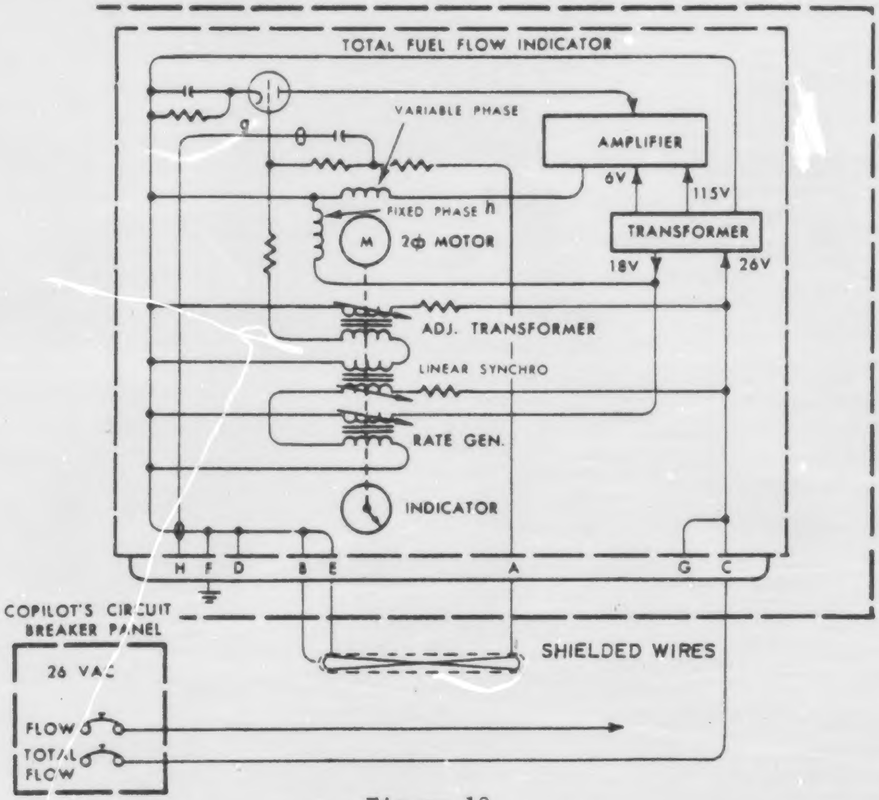

TOTAL FUEL FLOW INDICATOR
VARIABLE PHASE
g
AMPLIFIER
6V
115V
FIXED PHASE
h
M
2φ MOTOR
TRANSFORMER
18V
26V
ADJ. TRANSFORMER
LINEAR SYNCHRO
RATE GEN.
INDICATOR
H
F
D
B
E
A
G
C
COPILOT'S CIRCUIT BREAKER PANEL
26 VAC
FLOW
TOTAL FLOW
SHIELDED WIRES

Figure 19.

Refer to figure 19 and circle the letter of the correct response to the following statements.

1. The totalizer indicator transformer receives its voltage from the

   a. 26V AC power source.
   b. 28V DC power source.
   c. 110V AC power source.
   d. 115V AC power source.

2. The fixed phase of the induction motor and the rotor of the rate generator have

   a. 6V AC applied to them.
   b. 18V AC applied to them.
   c. 26V AC applied to them.
   d. 115V AC applied to them.

3. The necessary voltage for the totalizer indicator operation is supplied by the

   a. rate generator.
   b. linear synchro.
   c. indicator transformer.
   d. adjustable transformer.

4. The plate of the amplifier tube has

   a. 6V AC applied to it.
   b. 18V AC applied to it.
   c. 26V AC applied to it.
   d. 115V AC applied to it.

Answers to Frame 20: 1. b 2. b

Frame 22

The totalizer linear synchro is the signal nulling unit (that stops the pointer) in the indicator. The rotor of the synchro is excited by 26 volts AC from the aircraft power source through pin C of the electrical connector. Refer to figure 19. The stator output signal is used to cancel the signal from the linear synchro outputs of the transmitters. This signal is necessary to stop servoloop operation when the totalizer indicator reaches the proper indication. This is done by stopping current (cut-off) through the amplifier tube.

Circle the letter of the correct responses to the following statements.

1. The signal nulling unit in the totalizer indicator is the

    a. two-phase motor.
    b. linear synchro.
    c. adjustable transformer.
    d. rate generator.

2. The rotor of the linear synchro is energized from the

    a. autotransformer.
    b. amplifier.
    c. adjustable transformer.
    d. 26V AC power source.

Answers to Frame 21: 1. a 2. b 3. c 4. d

The totalizer adjustable transformer is used to adjust the output of the totalizer linear synchro to zero signal when the totalizer indicator pointer is at zero. The adjustable transformer, shown in figure 19, is a synchro unit with only two leads of the stator connected in the circuit. The rotor is excited by 26V AC from the aircraft power source through pin C of the connector. The stator is connected in series with the stator of the linear synchro. The rotor of this synchro is adjusted when the synchro is installed in the indicator at the factory and does not move. The rate generator "B" in the totalizer indicator, provides a dampening feedback signal to prevent the indicator pointers from overshooting and oscillating as the servoloop is nulled. Notice in figure 19 that the output phase of the rate generator is connected in series with the rotor of the linear synchro. As the rate generator turns, a voltage is produced in the output winding that is 180° out-of-phase with the linear synchro rotor excitation voltage. This out-of-phase voltage will subtract from the linear synchro rotor excitation voltage by an amount proportional to generator speed. (When the linear synchro rotor excitation voltage decreases, the voltage output of the linear synchro will decrease.) This keeps the motor from overspeeding and assures a smooth movement of the indicator pointers for small segments of travel.

Refer to figure 19 and circle the letter of the correct response to the following statements.

1. The rotor of the adjustable transformer is energized by

   a. 6V AC.
   b. 18V AC
   c. 26V AC.
   d. 115V AC.

2. The rotor of the adjustable transformer

   a. is fixed.
   b. moves with the rotor of the linear synchro.
   c. is driven by the 2-phase motor.
   d. is driven by the rate generator.

3. The totalizer adjustable transformer adjusts the output of the totalizer linear synchro to zero when the

   a. individual indicator pointer is at zero.
   b. totalizer indicator pointer is at zero.
   c. individual indicator pointer is at 3,000 pounds.
   d. totalizer indicator pointer is at 3,000 pounds.

Frame 23 (Continued)

4. The voltage produced by the variable phase of the rate generator and the excitation voltage of the linear synchro is

   a. in phase with each other.
   b. 45 degrees out of phase with each other.
   c. 90 degrees out of phase with each other.
   d. 180 degrees out of phase with each other.

5. What prevents the motor from overspeeding and assures a smooth movement of the pointers?

   a. A decrease in rate generator output voltage and a decrease in voltage applied to thy linear synchro rotor.
   b. A decrease in rate generator output voltage and an increase in the output voltage of thy linear synchro rotor.
   c. An increase in rate generator output voltage will subtract from excitation voltage applied to the linear synchro rotor.
   d. An increase in rate generator output voltage and a decrease in the 26 volts applied to the linear synchro rotor.

Answers to Frame 22: 1. b 2. d

Answers to Frame 23: 1. c 2. a 3. b 4. d 5. c

Go back to the beginning of this programmed text and review the frames. When you feel you know and understand the objective, you are ready to take an appraisal.

WORKBOOK

3ABR32531-WB-205
3ABR32632B-WB-305

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

FUEL FLOW INDICATING SYSTEM

1 September 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-205
3ABR32632B-WB-305

INSPECTION, OPERATIONAL CHECK, TROUBLESHOOTING AND BENCH CHECK OF THE FUEL FLOW INDICATING SYSTEM

OBJECTIVES

Given a workbook and trainer, perform an inspection and operational check of a fuel flow indicating system with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainer, troubleshoot the fuel flow indicating system with an accuracy of 75% correct workbook responses.

Given a workbook, test equipment, and trainer, bench check components of a fuel flow indicating system with an accuracy of 100% correct workbook responses.

EQUIPMENT

	Basis of Issue
Fuel Flow Indicator (from trainer)	1/student
Fuel Flow Trainer #2442	1/student
Multimeter and Leads	1/student
Test Set, Field Synchro	1/student
TO 33D2-6-105-1 EXTRACT	1/student
3ABR32531-WB-205 or 3ABR32632B-WB-305	1/student

PROCEDURE

Remove ALL JEWELRY and follow ALL safety precautions when working on electrical equipment. Be sure the trainer is not connected to the power source. Be sure ALL trouble switches on the trainer are in the OUT position. DO NOT go behind the trainer to perform the inspections. Obtain ALL test equipment from the instructor. DO NOT damage the trainer or test equipment.

Read and understand the TO EXTRACT, before proceeding with the bench check. Read ONLY that part of the TO EXTRACT that is referenced by this workbook. Some parts of the EXTRACT are not needed to complete this project. Place a checkmark (✓) on the proper blanks.

Supersedes 3ABR32531-WB-210, 3ABR32632B-WB-309, 14 August 1974, which may be used until existing stocks are exhausted.
OPR: 3360 TTG
DISTRIBUTION: X
3360TTGTC-W - 200; TTVSR - 1

Part 1. INSPECTION

		Satisfactory	Unsatisfactory
1.	Visually inspect the Totalizer Fuel Flow Indicator for:		
a.	Loose or cracked glass.		
b.	Security of mounting.		
c.	Condition of fluorescent markings.		
d.	Condition of pointer.		
2.	Visually inspect #4 Fuel Flow Indicator for:		
a.	Loose or cracked glass.		
b.	Security of mounting.		
c.	Condition of fluorescent markings.		
d.	Condition of pointer.		
3.	Visually inspect #4 Fuel Flow Transmitter for:		
a.	Dented or cracked case.		
b.	Security of mounting.		
c.	Damaged electrical connector.		
4.	Visually inspect #5 Fuel Flow Indicator for:		
a.	Loose or cracked glass.		
b.	Security of mounting.		
c.	Condition of fluorescent markings.		
d.	Condition of pointer.		
5.	Visually inspect #5 Fuel Flow Transmitter for:		
a.	Dented or cracked case.		
b.	Security of mounting.		
c.	Damaged electrical connector.		
6.	Visually inspect the electrical wiring for:		
a.	Frayed or broken wires.		
b.	Scorched or broken insulation.		
c.	Cracked or bent connector plug.		
d.	Security of mounting.		

Part 2. OPERATIONAL CHECK

1. Plug trainer into 26VAC 400 Hz outlet (drop cord).

2. Make sure all trouble switches are to the OUT position.

3. Push all three circuit breakers to the IN position.

4. Let totalizer warm up for one minute.

5. Slowly advance number 4 throttle to 10,000 PPH on #4 indicator.

   a. Totalizer indicator should indicate 10,000 PPH fuel flow ± 850 PPH.

   b. Totalizer indicator indicates __________ PPH fuel flow.

   c. System is Satisfactory ______, Unsatisfactory ______.

6. Retard #4 throttle to the closed position. Slowly advance #5 throttle to 10,000 PPH on indicator.

   a. Totalizer indicator should indicate 10,000 PPH fuel flow ± 850 PPH.

   b. Totalizer indicator indicates __________ PPH fuel flow.

   c. System is Satisfactory ______, Unsatisfactory ______.

7. Retard #5 throttle to the closed position.

8. Slowly advance both #4 and #5 throttles until each individual indicator reads 10,000 PPH.

   a. Totalizer indicator should indicate 20,000 PPH fuel flow ± 1,700 PPH.

   b. Totalizer indicator indicates __________ PPH fuel flow.

   c. System is Satisfactory ______, Unsatisfactory ______.

Part 3. TROUBLESHOOTING

1. Retard #4 and #5 throttles to the closed position.

2. Place trouble switch #1 to the IN position.

3. Slowly advance #4 throttle to the full position. Observe the indications on #4 fuel flow indicator and the totalizer fuel flow indicator while the throttle is being moved. Place a checkmark (✓) in the proper blanks in Chart 1.

4. Retard #4 throttle to the closed position and slowly advance #5 throttle to the full position. Observe the indications on the #5 fuel flow indicator and the totalizer indicator while throttle is being moved. Place a checkmark (✓) in the proper blank in Chart 1.

5. Retard #5 throttle and place trouble switch #1 to the OUT position.

Note; REPEAT the above steps for problems 2 through 8 and RECORD the indications in Chart 1.

Trouble Switch	#4 Indicator	#5 Indicator	Totalizer
1	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
2	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
3	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
4	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
5	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
6	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
7	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.
8	norm____, inop____, erratic____.	norm____, inop____, erratic____.	norm____, inop____, erratic____.

Chart 1.

Note: Have instructor CHECK your indications.

6. RETARD ALL throttles to the closed position.

7. Pull all circuit breakers, disconnect trainer from 26VAC, 400 Hz power source and remove the electrical connectors from the indicators and transmitters.

Note: Be sure ALL trouble switches are to the OUT position.

8. Connect the leads to the multimeter and zero the meter.

9. Troubleshoot the fuel flow indicating system by placing one trouble switch to the IN position at a time. Use the DIAGRAM on the trainer to aid you in troubleshooting.

a. Do not troubleshoot the "B" lead (shielded lead) at Totalizer Indicator.

b. When troubleshooting power leads, place one multimeter lead under Circuit Breaker terminal at the back of the trainer and the other lead in the applicable Test Point in front of the trainer.

10. Enter the wire number in the appropriate space and place a checkmark (✓) in the proper blank in column 3 (Kind of Trouble) of Chart 2.

11. Repeat the above procedure for problems 2 through 8.

Trouble Switch	Wire Number	Kind of Trouble
1		high resistance____, open____, shorted wires____.
2		high resistance____, open____, shorted wires____.
3		high resistance____, open____, shorted wires____.
4		high resistance____, open____, shorted wires____.
5		high resistance____, open____, shorted wires____.
6		high resistance____, open____, shorted wires____.
7		high resistance____, open____, shorted wires____.
8		high resistance____, open____, shorted wires____.

Chart 2.

Note: Have instructor check your indications.

12. Reconnect all connector plugs to the indicators and transmitters.

13. Remove leads from multimeter and place function switch to DC volts.

14. Place the range switch all the way to the right and return multimeter and leads to the cabinet.

15. Make sure all trouble switches are to the OUT position.

Part 4. BENCH CHECK

Note: For 3ABR32531 students ONLY.

1. Remove an individual fuel flow indicator from #1 trainer (next to radiator) for bench checking.

2. Obtain a Sychro Field Tester from tester storage cabinet in AC lab.

3. Refer to the EXTRACT of TO 33D2-6-105-1, Section IV, para 4-1 through 4-5 and figures 4-1 and 4-2 for OPERATION and TEST SET UP procedures.

4. Connect CABLE "A" to power input plug #10 on the tester.

5. Connect CABLE "C" to test unit plug #9 on the tester.

6. Connect CABLE "G" to CABLE "J".

7. Connect CABLE "J" to the Fuel Flow Indicator.

8. Plug CABLE "A" in to 115VAC 400 Hz outlet.

9. Switch "4" of the Synchro Field Test Set should be in CAL position and Test Set Switch #2 to the SYN IND position.

10. Turn power switch #17 ON at this time.

Fuel Flow Indicator

Range: 0-12000

Dial: A251-B16A

	FRICTION ERROR				SCALE ERROR			
PPH	Before Tap	After Tap	S	U	Trans. #1 Test	Exact °	S	U
0					15°			
400					47°			
800					79°			
1200					111°			
1600					143°			
2000					175°			
2075 (EZ)					180°			
2400					207°			
2800					239°			
5000					275°			
9000					315°			
11000					335°			

Chart 3.

EZ - Electrical Zero

EZ is satisfactory ____, unsatisfactory ____.

Position error is satisfactory ____, unsatisfactory ____.

The indicator is satisfactory ____, unsatisfactory ____.

11. To perform the Friction and Scale Error test, rotate the knob of transmitter #1 of the Synchro Field Test Set to bring the pointer to the desired indication. Two readings must be taken; the FIRST before taping the instrument and the SECOND after the instrument is taped.

a. The difference between the first and second readings must NOT exceed the friction tolerance of 1.5 degrees.

b. The second reading must NOT exceed the Scale Error tolerance of .75 degrees.

12. To perform the Position Error test, set the knob of Transmitter #1 of the Synchro Field Test Set at midscale. Take a reading with the indicator in a (normal) horizontal position. This reading should NOT differ from the readings with the indicator in any other position by more than the tolerance of .5 degrees.

If indications are NOT correct, adjust Trans #1 until indicator reads the EXACT PPH and record in exact degree column this degree reading.

13. Disconnect test equipment and stow leads.

14. Replace and connect fuel flow indicator in trainer.

15. Put test equipment away.

SECTION II

SPECIAL SERVICE TOOLS

(NOT APPLICABLE)

SECTION III

PREPARATION FOR USE, STORAGE, OR SHIPMENT

3-1. PREPARATION FOR USE.

3-2. Unpack the Test Set from the shipping container and swing back the protective cover to see that all the cables listed in figure 1-4 are in the cable storage compartment adjacent to the instrument panel. Make sure that the booklet of calibration tables has been included. Allow sufficient space around the Test Set for connecting the test cables to units under test.

3-3. The Test Set requires a power source of either 115 volts or 26 volts, 400 cps, single phase. Power consumption is approximately 25 watts.

3-4. STORAGE OR SHIPMENT.

3-5. Refer to specification MIL-P-116C for general requirements covering the preservation of equipment against corrosion during shipment and storage.

SECTION IV

OPERATION INSTRUCTIONS

4-1. GENERAL.

4-2. The instructions given in this section refer to the operation of the Test Set, and are not intended to serve as test procedures for the unit under test. When the Test Set is used in an aircraft, the booklet of calibration tables provided will serve as a convenient guide for test values to be obtained from the unit under test. Refer to the applicable technical manual on the unit under test for specific test instructions, test values, and permissible tolerances.

4-3. OPERATING CONTROLS, INDICATORS, AND CONNECTIONS.

4-4. All the operating controls, indicators, and connecting points of the Test Set are illustrated in figure 4-2 and their function is given in figure 4-1. In addition to the items listed, two 1-ampere fuses and one 3/8-ampere fuse are fitted on the instrument panel. Two spare fuses, one for each type, are also included.

4-5. TEST SETUP PROCEDURES.

a. Set all switches and controls to OFF or fully counterclockwise position.

b. Connect test adapter cable QB86030-1 to the TEST UNIT connector on the panel of the Test Set.

CAUTION

Understand the entire operation before starting to test a unit.

4-6. SYNCHRONOUS INDICATOR TEST PROCEDURES.

a. Disconnect the cable from the indicator under test in the aircraft.

b. If a single indicator is to be tested, connect Autosyn Synchro test cable QB84998-1 between test adapter cable QB86030-1 and the indicator. Connect power source cable QB86032-1 to the disconnected aircraft cable and to the POWER-INPUT 10 connector through adapter cable QB86063-1.

c. If a dual indicator is to be tested, connect dual indicator test cable QB86029-1 between test adapter cable QB86030-1 and the indicator. Connect power source cable QB86031-1 to the disconnected

REPRODUCTION FOR ATC TRAINING USE ONLY. DO NOT USE ON THE JOB.

CONTROL NOMENCLATURE	FUNCTION
Autosyn transmitter 1	Establishes standard against which synchronous and servoed indicators are tested.
TEST SEL switch	Selects the test circuitry for the unit under test. The SYN IND position is used for testing synchronous indicators; the SERVO position is for testing servoed indicators; the MOTOR position is for testing low inertia motors; the TRANS position is for testing transmitters; and the DIFF. position is for testing differentials.
Servoed Autosyn indicator 3	Used as standard for testing accuracy of transmitters and differentials under test.
SYN IND switch 4	Selects the test circuitry for the type of test being performed on synchronous indicators. The E-Z position is used for checking electrical zero, and the CAL position is used when performing calibration tests.
MOTOR VOLTS FXD 5 control	Varies voltage applied to fixed-phase windings of low inertia motors when MOTORS VOLTS switch is in FIXED ø position.
MOTOR VOLTS VAR 6 control	Varies voltage applied to variable-phase windings of low inertia motors when MOTOR VOLTS switch is in VAR ø position.
MOTOR VOLTS 7 switch	Enables monitoring and adjustment of low inertia motor phase voltage at vtvm binding posts.
AMPL GAIN 8 control	Varies gain of servo amplifier in Test Set.
TEST UNIT 9 connector	Provides connection on Test Set to unit under test.
POWER-INPUT 10 connector	Provides connection on Test Set to power source.
POWER 16 lamp	Provides indication that Test Set is energized when POWER Switch is ON.
POWER 17 switch	Controls input power to the Test Set.
26V 18 and 19 binding posts	Provide connection for monitoring test circuits for 26 volts.
10.8V 19 and 20 binding posts	Provides connection for monitoring test circuits for 10.8 volts.
VTVM 21 and 22 binding posts	Provide connections for monitoring motor fixed-phase voltage, variable phase voltage, and servo nulls.

Figure 4-1. Operating Controls, Indicators, and Connections

aircraft cable and to the POWER-INPUT 10 connector through adapter cable QB86063-1.

d. See that aircraft power is on.

e. Set the POWER 17 switch on the Test Set to ON. The POWER 16 lamp should come on, indicating that the Test Set is energized. Using a vtvm or voltohmmeter, check a-c voltages at 26V 18 and 19 binding posts for 26 volts ±10 percent and at 10.8V 19 and 20 binding posts for 10.8 volts ±10 percent.

Note

If the indicator is tested on a test bench rather than in an aircraft, use power source

816

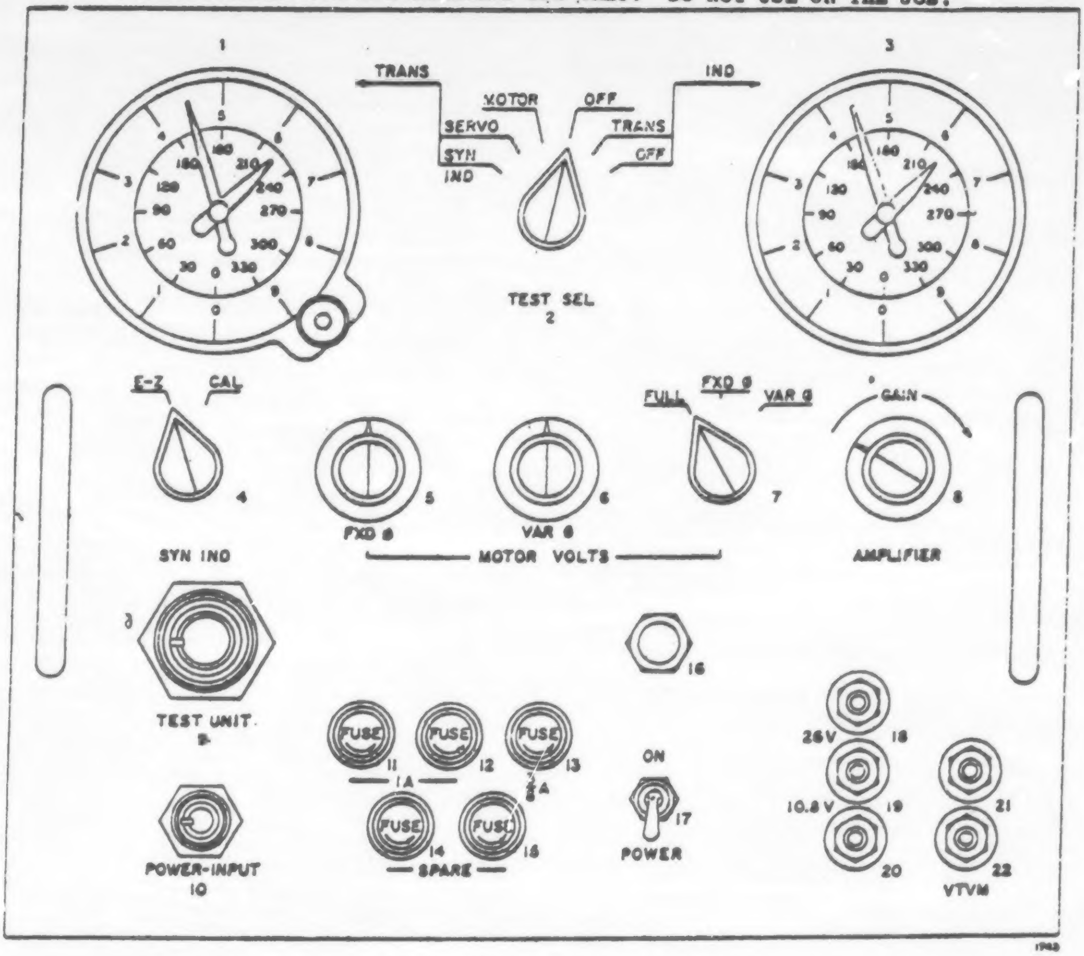

1
TRANS
MOTOR
SERVO
SYN
IND
OFF
TRANS
OFF
IND
3
TEST SEL
2
E-Z
CAL
FULL
FXD Ø
VAR Ø
GAIN
4
5
6
7
8
FXD Ø
VAR Ø
SYN IND
MOTOR VOLTS
AMPLIFIER
TEST UNIT
16
FUSE
11
12
13
1A
2A
14
15
SPARE
ON
17
POWER
26V
18
10.8V
19
20
21
22
VTVM
POWER-INPUT
10
1943

Figure 4-2. Synchro Instrument Field Test Set, Type 13819-2A, Front Panel

cable QB86062-1 to connect to a 115-volt, 400 cps power supply, and disregard power source cables QB86031-1, QB86032-1, and QB86033-1.

4-7. ELECTRICAL ZERO CHECK.

a. Set the TEST SEL switch to SYN IND and the SYN IND 4 switch to E-Z.

b. The indicator under test will assume its electrical zero position. Check the value against the calibratio[illegible]alue for the unit under test.

4-8. [illegible]GLE CHECK.

a. Set the SYN IND 4 switch to CAL, and rotate the test set transmitter "1" to the angles specified for the unit under test, using the calibration booklet for the proper angle settings.

b. The indicator under test should follow the Test Set transmitter within the applicable tolerances specified in the technical manual for the indicator under test.

c. Turn POWER 17 switch to OFF (down) position.

d. Remove connections from unit under test.

4-9. SERVOED INDICATOR ANGLE CHECK.

a. Disconnect the cable from the servoed indicator under test in the aircraft.

b. Connect servoed indicator test cable QB84967-1 between test adapter cable QB86030-1 and the servoed indicator under test.

c. Set TEST SEL 2 switch to SERVO.

837

d. Connect power source cable QB86033-1 to the disconnected aircraft cable.

e. Set the POWER 17 switch to ON.

f. Check power supply voltages at 26V 18 and 19 binding posts for 26 ±10 percent volts and at 10.8V 19 and 20 binding posts for 10.8 ±10 percent volts.

g. Turn AMPL GAIN 8 control fully clockwise. Allow the SERVO amplifier to warm up for at least one minute

Note

> The signal input voltage to the amplifier can be monitored by connecting a vtvm across the VTVM 21 and 22 binding posts.

h. Rotate the Test Set transmitter 1 to the angles specified in the calibration booklet for the servoed indicator under test.

i. The servoed indicator should follow the test set transmitter settings within the applicable tolerance specified for the indicator under test.

4-10. LOW INERTIA MOTOR DIRECTION TEST.

a. Set TEST SEL 2 switch to MOTOR.

b. Set MOTOR VOLTS 7 switch to FULL to apply 26 volts to the motor windings. The pointers of the servoed indicator under test should move in a clockwise direction.

4-11. LOW INERTIA MOTOR FIXED PHASE STARTING VOLTAGE TEST.

a. Set MOTOR VOLTS 7 switch to FXD Ø.

b. Set MOTOR VOLTS VAR Ø 6 control fully clockwise.

c. Slowly rotate FXDØ MOTOR VOLTS control 5 clockwise until the pointers of the indicator under test begin to move. Monitor the fixed-phase starting voltage at VTVM 21, 22, binding posts and compare the value with the specification value.

4-12. LOW INERTIA MOTOR VARIABLE PHASE STARTING VOLTAGE TEST.

a. Set MOTOR VOLTS VAR Ø 6 control and MOTOR VOLTS FXD Ø 5 control fully counterclockwise.

b. Set MOTOR VOLTS 7 switch to VARØ .

c. Set MOTOR VOLTS FXD Ø 5 control fully clockwise.

d. Slowly move MOTOR VOLTS 6 control clockwise until the pointer of the indicator under test begins to move. Monitor the variable phase starting voltage across the VTVM 21, 22 binding posts. Compare the value with the specification requirement. In no case should the starting voltage (fixed or variable phase) exceed 200 millivolts.

e. Set POWER 17 switch to off (down) position.

4-13. TRANSMITTER TEST PROCEDURE.

a. Disconnect the cable from the transmitter or differential under test in the aircraft.

b. Connect power source cable QB86032-1 to the disconnected aircraft cable and to the POWER-INPUT 10 connector through adapter cable QB86063-1.

c. Connect Autosyn synchro test cable QB84998-1 between test adapter cable QB86030-1 and the unit under test.

d. Set the TEST SEL 2 switch to TRANS.

e. Set the POWER 17 switch to ON.

f. Check power supply voltages as described in paragraph 4-9, step f.

g. Turn the AMPL GAIN 8 control fully clockwise. Allow the servo amplifier to warm up for at least one minute before proceeding.

h. Rotate the unit under test to the angles specified for that unit in the test specifications and see that the Test Set indicator shows the required values.

i. On completion of tests, set all switches to their OFF or fully counterclockwise positions and remove connections from unit tested.

4-14. DIFFERENTIAL TEST PROCEDURE.

When the Test Set is used to test differential Autosyns synchros, use the procedure described in paragraph 4-13, for transmitters, but set the TEST SEL 2 switch to DIFF.

PROGRAMMED TEXT
3ABR32531-PT-206

Technical Training

Avionics Instrument Systems Specialist

ENGINE PRESSURE RATIO SYSTEM

4 May 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

8/19

Flight Training Devices/Instrument Branch
Chanute Air Force Base, Illinois

PROGRAMMED TEXT
3ABR32531-PT-206

OBJECTIVES

Without references, identify facts pertaining to the purpose, operation, and/or characteristics of typical engine pressure ratio systems with an accuracy of 70%.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading the information in each frame, you are asked to actively respond in this booklet. Check the accuracy of your response with the correct answers that are given in the following frame. If you make an incorrect response, study the frame again before going on to the next frame. DO NOT HURRY!

Supersedes 3ABR32531-PT-206, 3ABR32632B-PT-306, 22 August 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 300; TTVSA - 1

Frame 1

Today's modern aircraft have several instruments installed to monitor engine performance. On early propeller driven aircraft, horsepower was computed with readings taken from the tachometer (rpm) and the torque pressure indicator. As time progressed, the jet engine was introduced. On early jet engines, tachometer (rpm), fuel flow and exhaust gas temperature indicators provided the pilot with an indication of engine efficiency, but from these indications, the power output of the engine can only be estimated. The only accurate method of determining the thrust produced by a jet engine is to measure the ratio of engine inlet pressure to engine exhaust gas pressure. The engine pressure ratio (EPR) system was designed for this purpose.

Circle the correct letter for the following statements.

1. The purpose of the engine pressure ratio system is to measure the ratio between the inlet air

   a. pressure and exhaust gas temperature.
   b. pressure and exhaust gas pressure.
   c. temperature and exhaust gas temperature.
   d. temperature and exhaust gas pressure.

Frame 2

The engine pressure ratio (EPR) system is made up of an inlet probe, exhaust probe, transducer and indicator. See figure 1. We will learn about each of these items in the following frames.

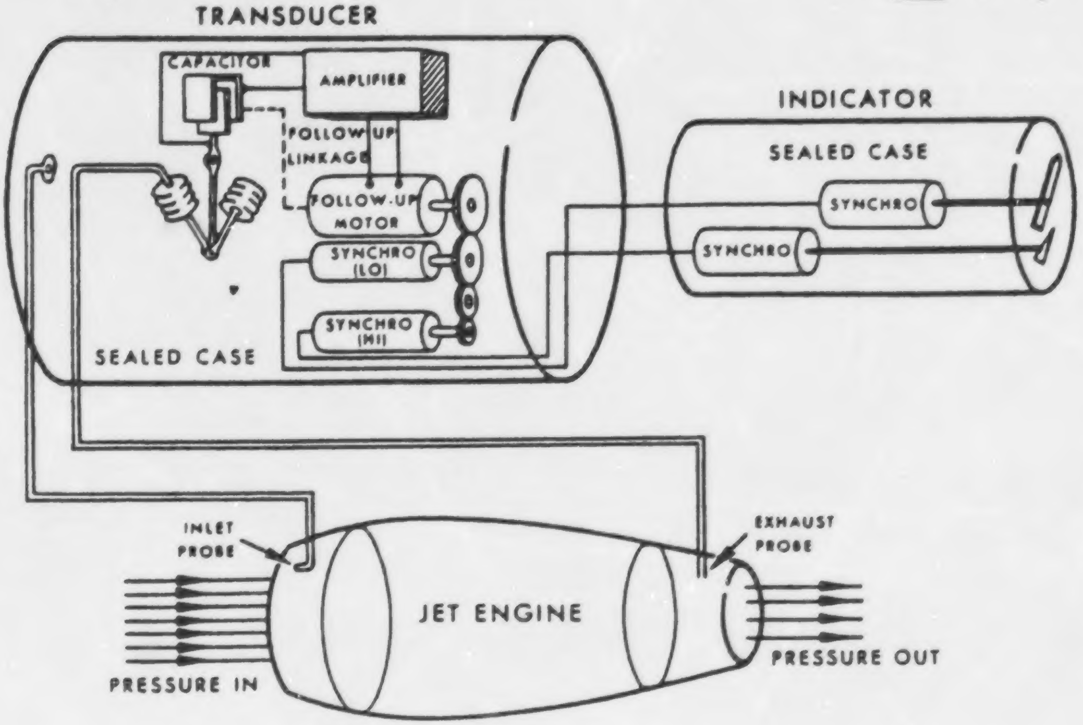

TRANSDUCER
CAPACITOR
AMPLIFIER
FOLLOW-UP LINKAGE
FOLLOW-UP MOTOR
SYNCHRO (LO)
SYNCHRO (HI)
SEALED CASE
INDICATOR
SEALED CASE
SYNCHRO
SYNCHRO
INLET PROBE
EXHAUST PROBE
JET ENGINE
PRESSURE IN
PRESSURE OUT

Figure 1.

NO RESPONSE REQUIRED

Answer to Frame 1: 1. b

The EPR systems four main components are:

1. inlet probe (P_{t2}).
2. exhaust probe (P_{t7}).
3. indicator.
4. transducer.

They are located on a typical aircraft as shown in figure 2.

The transducer is mounted near the engine and receives P_{t2} and P_{t7} pressures through stainless steel tubing. It converts the difference between these two pressures into electrical signals. The indicator on the instrument panel uses these transducer signals to present EPR indications.

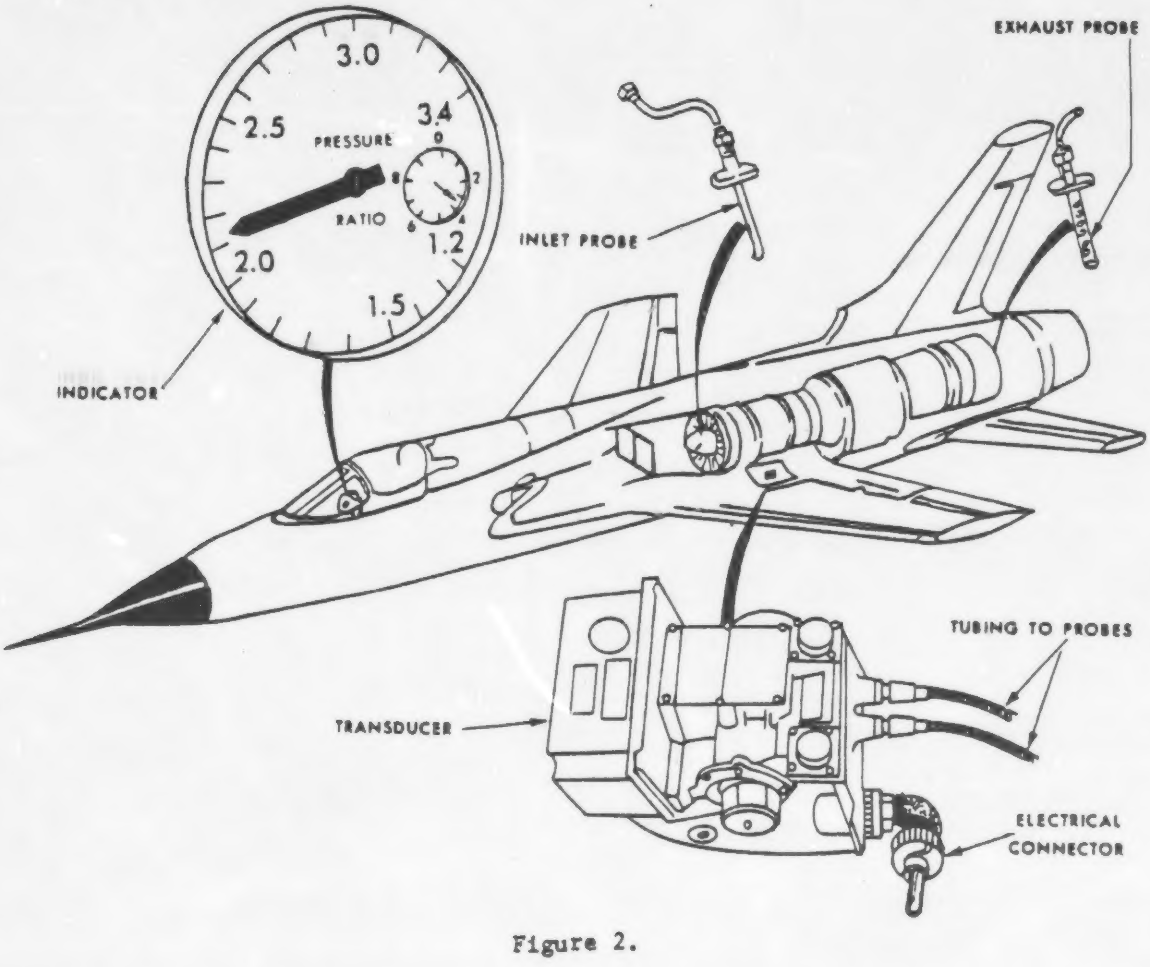

3.0
2.5
3.4
PRESSURE
RATIO
2.0
1.2
1.5
0
2
4
6
8
INDICATOR
INLET PROBE
EXHAUST PROBE
TUBING TO PROBES
TRANSDUCER
ELECTRICAL CONNECTOR

Figure 2.

Frame 3 (Continued)

Circle the correct answers to the following responses.

1. The exhaust pressure probe and transducer are connected by

   a. electrical wire.
   b. steel tubing.
   c. rubber hose.
   d. copper pipe.

2. While in the process of replacing a transducer, you would be working

   a. in the pilot's compartment.
   b. in the exhaust tail pipe.
   c. back of the propeller.
   d. near the engine.

3. Inlet and exhaust pressures are applied directly to the

   a. transducer.
   b. indicator.
   c. indicator and transducer.
   d. engine.

4. Exhaust pressure is

   a. applied to the indicator.
   b. P_{t7}.
   c. less than atmospheric pressure.
   d. P_{t2}.

Pressure ratio systems are used on jet engine powered aircraft. Inlet and exhaust pressures are "picked up" by small tubes (probes) inserted into the engine as shown in figure 3. Inlet pressure is referred to as P_{t2} and is the total inlet pressure at engine station number 2. Exhaust pressure is referred to as P_{t7}, and is the total pressure at engine station number 7. When the engine is operating, P_{t7} is greater than P_{t2}.

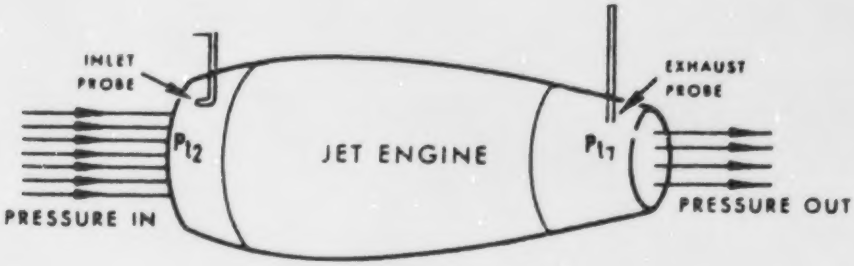


Figure 3.

1. Select the correct response.

   a. If pressure in ONE probe is 14 PSI and the other probe is 6.0 PSI, 14 PSI pressure is on the P_{t2} probe.
   b. A B-52 jet aircraft would use a pressure ratio system.
   c. Inlet pressure is greater than P_{t7} pressure.
   d. Pressure ratio is a measure of reciprocating engine thrust.

Answers to Frame 3: 1. b 2. d 3. a 4. b

Frame 5

Since engine pressure ratio is an accurate means of determining the thrust produced by a jet engine, the EPR indicator in the cockpit is a valuable aid to the pilot. By observing the EPR indications, the pilot can fly his aircraft more efficiently and safely. From performance charts in the flight manual, the pilot can determine the takeoff (thrust) pressure ratio number. By setting the throttle to obtain this EPR number on the EPR indicator, the pilot is assured of having the proper thrust for takeoff. On multi-engine aircraft, the pilot can set the same EPR number on all engines to maintain engine balance. Figure 4 shows the EPR indicator with the vernier dial.

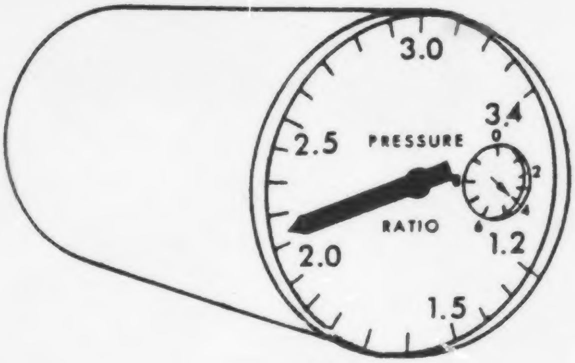


Figure 4.

Refer to figure 4 and complete the following statements.

1. The main dial of the indicator is graduated from

   a. 1.0 to 3.4.
   b. 1.2 to 3.4.
   c. 2.2 to 3.4.
   d. 2.3 to 3.4.

2. The EPR indicator indicates to the pilot (during engine operation) the proper

   a. rpm for takeoff.
   b. oil pressure for takeoff.
   c. thrust for takeoff.
   d. torque pressure for takeoff.

Answers to Frame 4: 1. b

Frame 5 (Continued)

Circle the correct answer(s) to the following statements.

3. The engine pressure ratio (EPR) system is an aid to the pilot. It enables him to
    - a. set the throttles for proper torque pressure.
    - b. set the throttles for proper engine balance (equal power output from all engines on multi-engine aircraft).
    - c. set the throttles for the greatest amount of thrust during cruise.
    - d. detect loss of engine thrust.

4. One use of the engine pressure ratio system is to
    - a. prevent engine overheating.
    - b. prevent engine overspeeding.
    - c. enable the pilot to set the throttles for takeoff thrust.
    - d. control engine oil pressure during cruise condition.

Frame 6

Indicators with vernier dials have the main dial graduated from 1.2 to 3.4 pressure ratio units. Each increment (mark) represents .1 EPR unit. The vernier dial has 10 increments and each increment represents .01 EPR unit. See figure 5. Since the vernier pointer makes one complete revolution for each graduation of main pointer movement, the vernier pointer moves much faster. The synchro that drives the vernier pointer is called the high speed indicator synchro. The synchro that drives the main pointer is called the low speed indicator synchro. As in all synchros, each of the indicator synchros contain a "wye" connected stator and a coil rotor. Each rotor shaft is directly connected to the indicator pointer that it drives. There are no mechanical stops to limit either pointer. See figure 5 and figure 6 to see how the synchros are connected to the pointers.

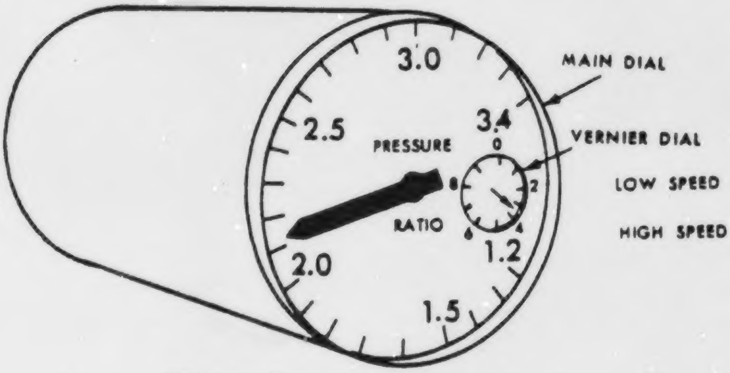


Figure 5.

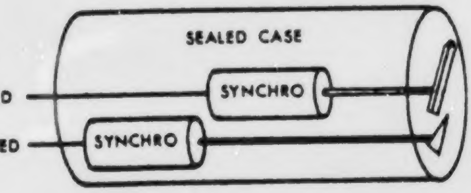


Figure 6.

Refer to figures 5 and 6 to complete the following statements.

1. For each complete revolution of the vernier pointer, the main pointer will move

   a. one-half increment.
   b. one increment (graduation).
   c. one-half revolution.
   d. one revolution.

2. The high speed indicator synchro moves

   a. the small pointer.
   b. the large pointer.
   c. both pointers at the same time.

3. The large pointer of the indicator is driven by

   a. the low speed synchro.
   b. the high speed synchro.
   c. both synchros.

Answers to Frame 5: 1. b 2. c 3. b 4. c

You may be confused as to the meaning of the number on the dial. The following is an explanation: They mean simply this - If you divide P_{t7} by P_{t2} your answer is the ratio of the two pressures. For example, if P_{t7} pressure is 6.9 and P_{t2} is 3.0 inches of mercury, their ratio is $\frac{6.9}{3.0} = 2.3$. The indicator then, reads 2.3 EPR units with these pressures applied to the operating transducer. See figure 7.

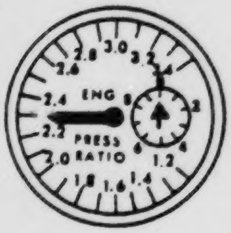


Figure 7.

Complete the following statement by filling in the blank.

1. The indicator in figure 7 indicates _____ EPR units.

Answers to Frame 6: 1. b 2. a 3. a

Frame 8

Engine pressure ratio transducers are manufactured by several different companies. Figures 9 and 10 illustrate two commonly used transducers manufactured by AiResearch and Minneapolis-Honeywell. Although these two components are physically different, their operation is very similar. These two transducers are interchangeable. Both of these transducers require 115 volt, 400-Hertz single-phase AC power for operation. Neither transducer is hermetically sealed and can be disassembled for maintenance.

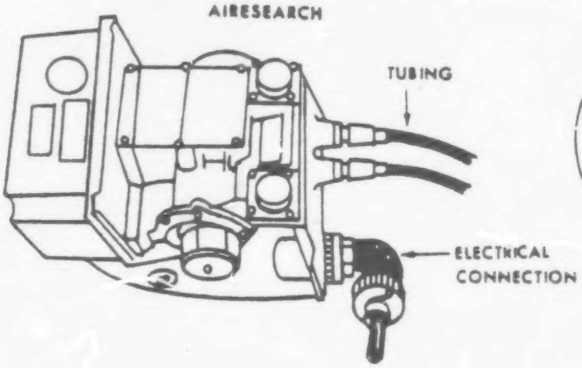

AIRESEARCH
TUBING
ELECTRICAL CONNECTION

Figure 8.

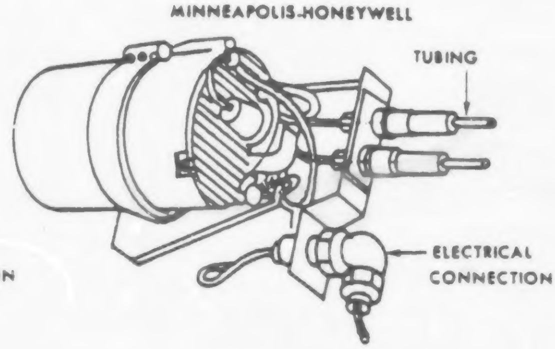

MINNEAPOLIS-HONEYWELL
TUBING
ELECTRICAL CONNECTION

Figure 9.

Refer to figures 8 and 9 to complete the following statement.

1. The transducers shown in figures 8 and 9
   a. look the same.
   b. are interchangeable.
   c. have one tube and one electrical connector.
   d. have two tubes and are physically the same.

Answer to Frame 7: 2.3

Frame 9

The transducer we are going to discuss is manufactured by AiResearch. The transducer converts the ratio between the inlet and the exhaust pressure into an electrical signal to operate the two synchros in the indicator. In the following frames we are going to discuss the units inside the transducer and how they work. Figure 10 shows the AiResearch transducer.

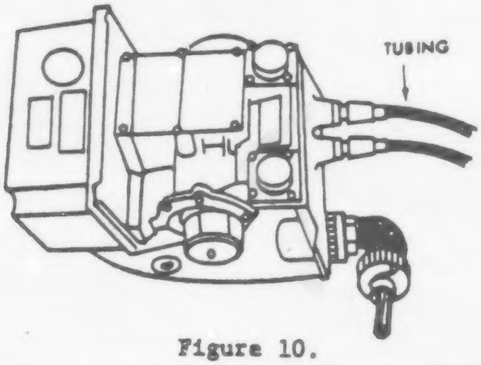


Figure 10.

Circle the letter preceding the correct response.

1. The purpose of the EPR transducer is to

   a. convert an electrical signal to a pressure ratio.
   b. indicate the rpm of the engine.
   c. convert a pressure ratio into an electrical signal.
   d. indicate the fuel pressure to the engine.

Answers to Frame 8: 1. b

Frame 10

The AiResearch transducer illustrated below in figure 11 uses a beam, pressure bellows and movable fulcrum to convert pressures (P_{t2} and P_{t7}) into mechanical movement. The balance beam is the horizontal bar in the center of the figure. The movable fulcrum supports its left end. "Resistance" is applied to the top side of the beam as P_{t7} and P_{t2} pressures are applied to the high side pressure bellows. P_{t2} pressure is also applied to the evacuated bellows. Effort is applied to the underside of the beam as P_{t2} and/or P_{t7} pressures actuate the low side pressure bellows. As P_{t2} and/or P_{t7} pressure changes, the forces applied to the beam change and the beam becomes unbalanced (tilted). An electric motor in the transducer then moves the fulcrum in the direction to rebalance the beam.

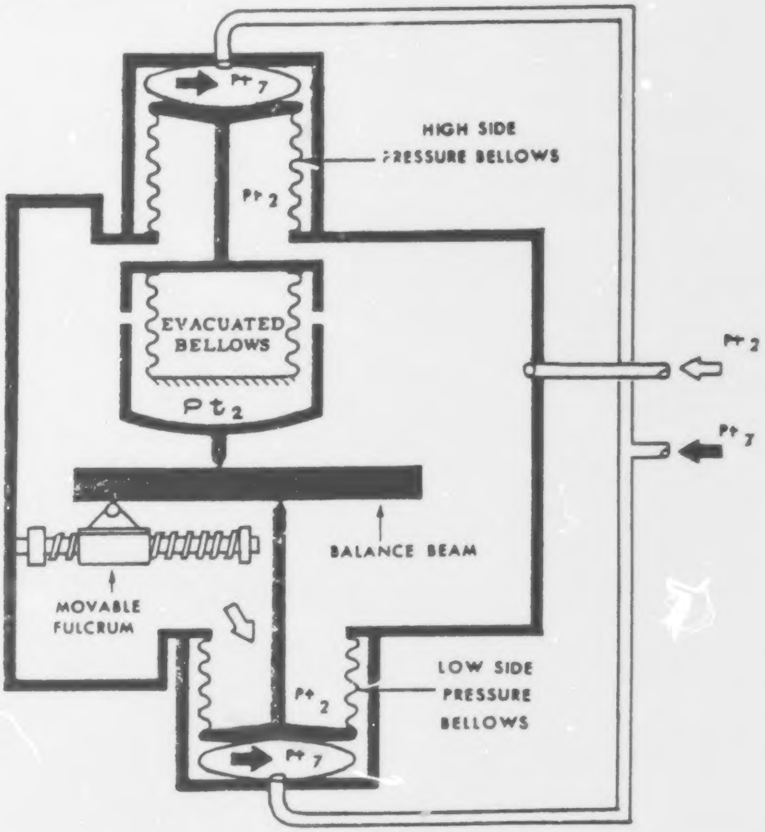

Pt 7
HIGH SIDE
PRESSURE BELLOWS
Pt 2
EVACUATED
BELLOWS
Pt 2
Pt 2
Pt 7
BALANCE BEAM
MOVABLE
FULCRUM
LOW SIDE
PRESSURE
BELLOWS
Pt 2
Pt 7

Figure 11.

Complete the following statements by filling in the blank spaces. Refer to figure 10 for information if necessary.

1. P_{t2} is jet engine ______ _______ pressure.
2. P_{t7} is jet engine _____________ pressure.
3. When pressures change, the beam ______________.
4. When the beam tilts the _______ moves to rebalance the beam.
5. The beam tilts when P_{t2} or P_{t7} pressures expand or contract the ___________.
6. A ____________ moves the fulcrum.
7. The fulcrum is always moved in the direction to ___________ the beam.
8. Surrounding the outside of the evacuated bellows is _______ pressure.
9. P_{t7} pressure is applied to the _______ of the two pressure bellows.
10. P_{t2} pressure is applied to the _______ of the two pressure bellows.
11. The schematic shown in figure 12 is a transducer manufactured by ___________ company.
12. Forces that unbalance the beam are produced by P_{t2} and P_{t7} pressures applied to the ___________.

Answers to Frame 9: 1. c

Frame 11

A schematic of the AiResearch transducer is shown in figure 12. Notice the DC motor and the mechanical arrangement used to turn the jackscrew and thus move the fulcrum. Note also the contactor assembly of one end of the beam. The beam is electrically grounded and, when tilted, grounds one contact or the other.

The functions of the electrical system within the transducer are listed below:

1. An electronic power source within the transducer furnishes DC voltage to the transistors and motor and AC voltage to the synchros. The power transformer steps down the AC voltage, which is changed to DC by TWO rectifiers.

2. The motor control circuits start and stop the motor and control the direction of rotation. These circuits consist of a contactor assembly, two transistors, the motor coil, and their connections to the power transformer.

The two transistors control motor current. Both transistors have reverse bias. In this reverse bias condition (as shown in figure 12) they act as open switches, so that the motor will not operate.

Mark the following statements true (T) or false (F).

_____1. The motor that turns the jackscrew operates on DC.

_____2. The rectifier converts AC to DC.

_____3. P_{t7} is applied to the inside of the pressure bellows.

Answers to Frame 10: 1. inlet 2. exhaust 3. tilts 4. fulcrum

5. bellows 6. motor 7. rebalance

8. P_{t2} 9. outside 10. inside 11. AiResearch

12. bellows

This illustration is to be used in frame 11.

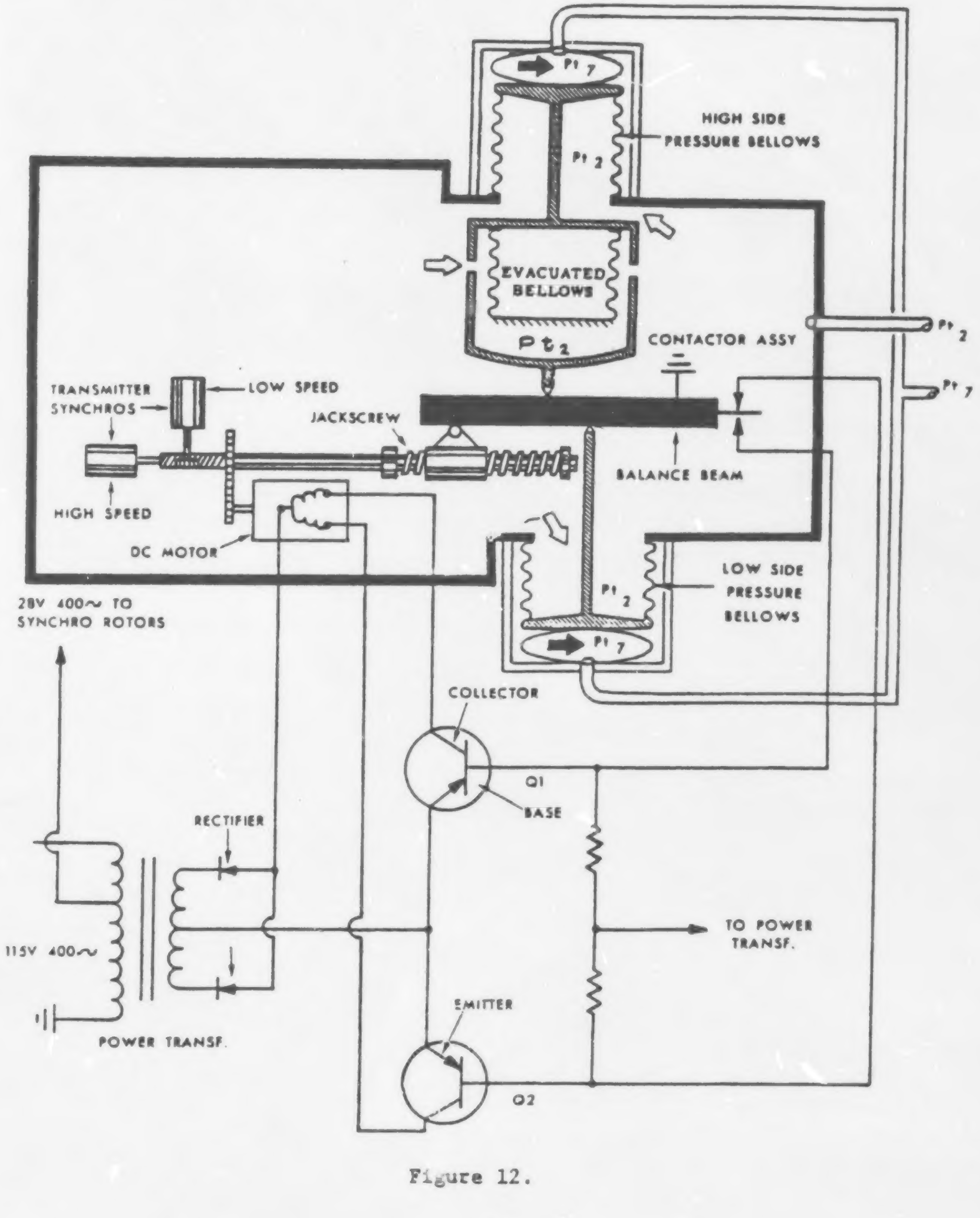

Pt 7
HIGH SIDE
PRESSURE BELLOWS
Pt 2
EVACUATED
BELLOWS
Pt2
Pt 2
Pt 7
CONTACTOR ASSY
TRANSMITTER
SYNCHROS
LOW SPEED
JACKSCREW
HIGH SPEED
BALANCE BEAM
DC MOTOR
LOW SIDE
PRESSURE
BELLOWS
Pt 2
Pt 7
28V 400~ TO
SYNCHRO ROTORS
COLLECTOR
Q1
BASE
RECTIFIER
TO POWER
TRANSF.
115V 400~
POWER TRANSF.
EMITTER
Q2

Figure 12.

Frame 12

Figure 13 is an illustration of the events that occur when the beam is unbalanced and the fulcrum is moving to a lower EPR position. (Arrows portray current flow in the motor circuit.) As the motor turns, the TWO synchro transmitter rotors turn to generate indicator synchro signals.

When P_{t7} pressure decreases, the balance beam tilts down, the lower contactor assembly is grounded as shown in figure 13. The transistor Q1 now has forward bias and acts as a CLOSED switch. Current flows through the motor, the motor runs to rebalance the beam and opens the ground lead stopping the DC motor.

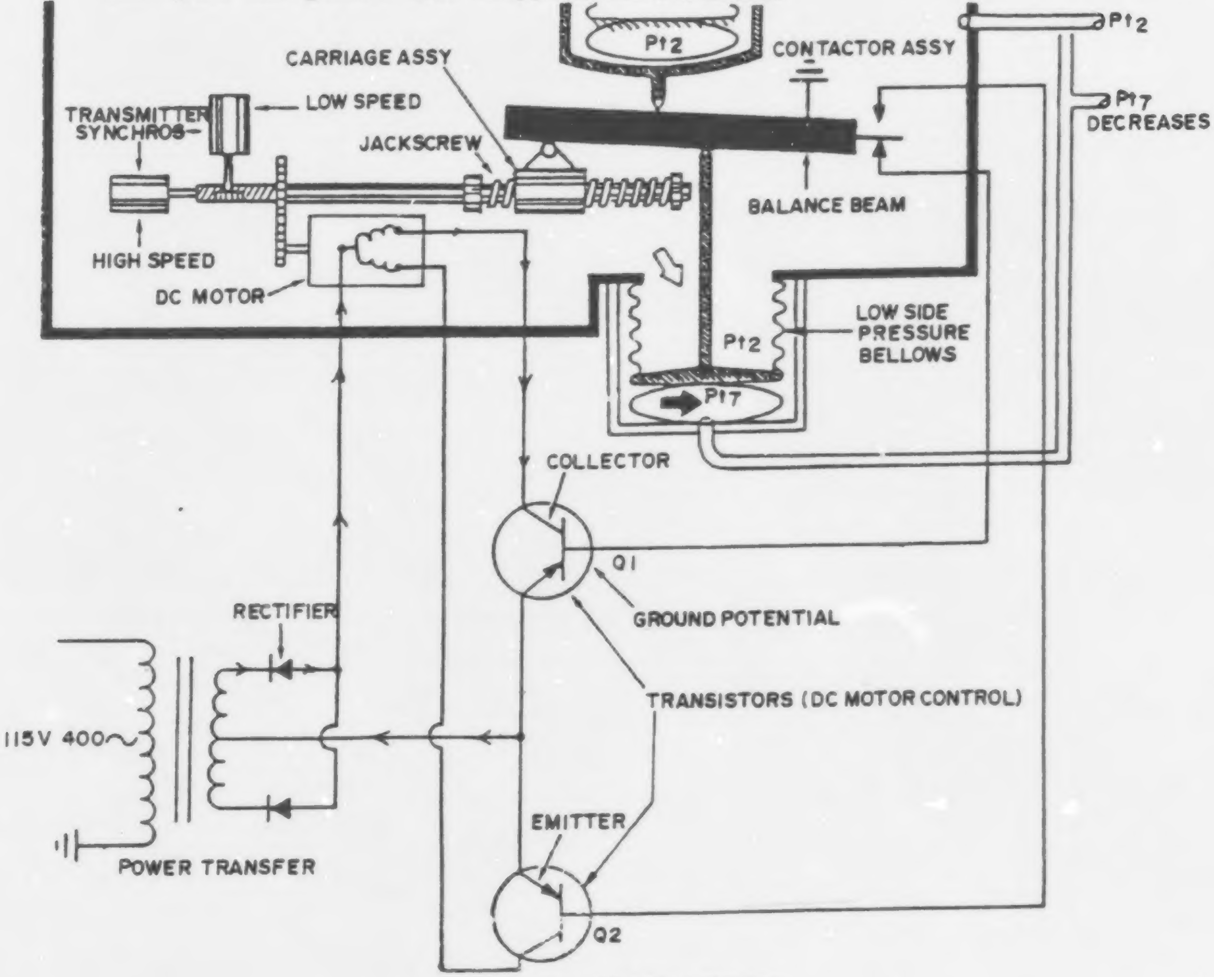

Pt2
CARRIAGE ASSY
CONTACTOR ASSY
Pt2
TRANSMITTER SYNCHROS
LOW SPEED
Pt7
DECREASES
JACKSCREW
BALANCE BEAM
HIGH SPEED
DC MOTOR
LOW SIDE PRESSURE BELLOWS
Pt2
Pt7
COLLECTOR
Q1
GROUND POTENTIAL
RECTIFIER
TRANSISTORS (DC MOTOR CONTROL)
115V 400~
EMITTER
POWER TRANSFER
Q2

Figure 13.

Complete the following statements by filling in the blanks.

1. The transducer has _________ transistors.
2. The contactor assembly is located on one end of the _________.
3. The beam is electrically ___________.

Answers to Frame 11: T 1. T 2. F 3.

See figure 14. The balance beam upper contacts (as shown) are closed when P_{t7} pressure increases. This ground provides forward bias for Q2 transistor allowing the DC motor to run, moving the fulcrum, repositioning the beam to NULL (centered position), opening the ground lead and stopping the DC motor.

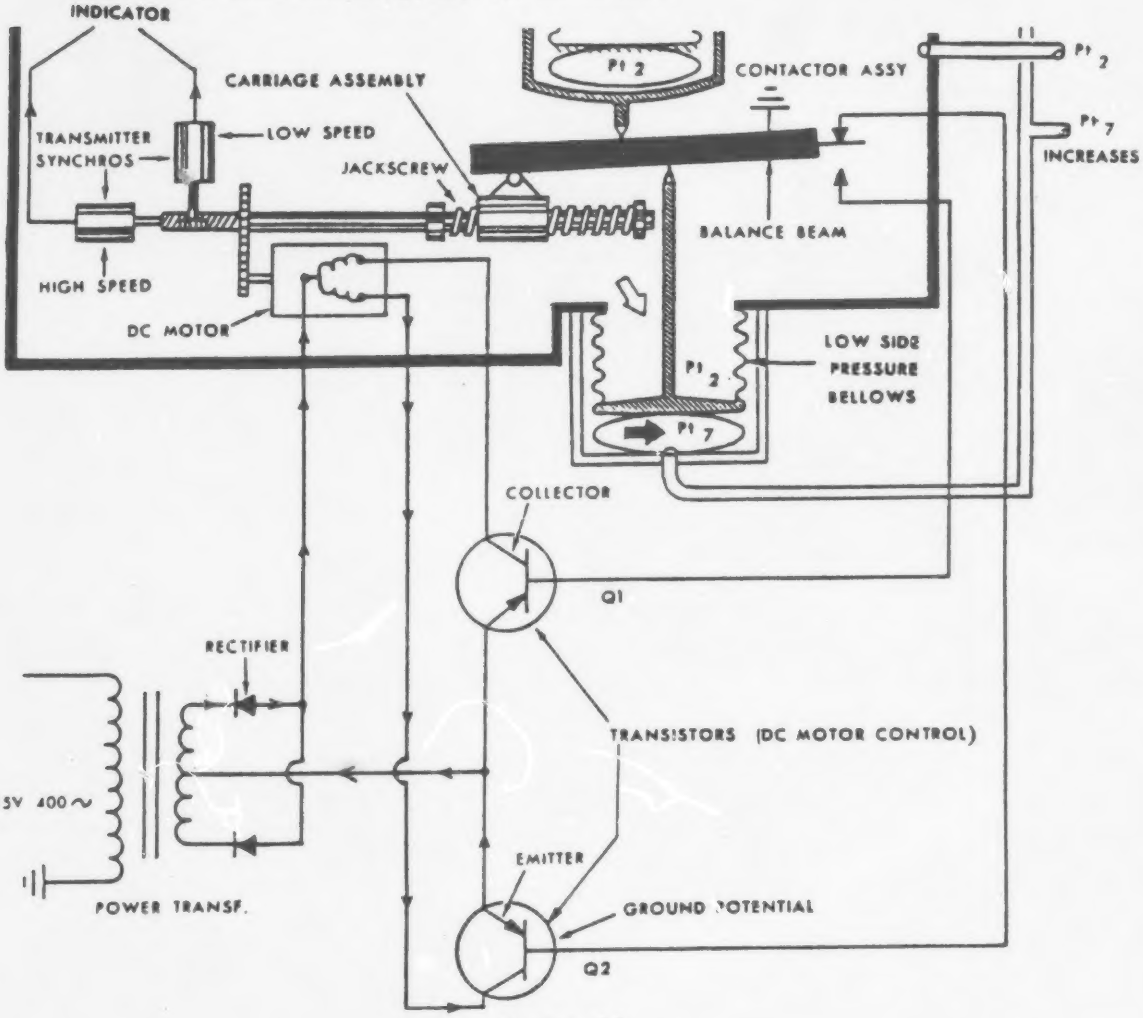

INDICATOR
CARRIAGE ASSEMBLY
CONTACTOR ASSY
Pt 2
Pt 2
Pt 7
INCREASES
TRANSMITTER SYNCHROS
LOW SPEED
JACKSCREW
HIGH SPEED
BALANCE BEAM
DC MOTOR
LOW SIDE PRESSURE BELLOWS
Pt 2
Pt 7
COLLECTOR
Q1
RECTIFIER
TRANSISTORS (DC MOTOR CONTROL)
115V 400~
EMITTER
GROUND POTENTIAL
POWER TRANSF.
Q2

Figure 14.

Complete the following statements by filling in the blanks.

1. The transistors are used as electrical ____________.
2. Indicator voltage signals are generated in the synchro ________________.
3. Components of the EPR system include a _______ and an _____________.
4. _________ bias causes the _______ to stop, which ______ the beam.

Frame 13 (Continued)

Refer to figure 14 to complete the following statement.

Circle the correct answer to the following responses.

5. With the DC motor running, the jackscrew will turn and the moveable fulcrum will re-center the beam and

   a. remove the ground from Q2.
   b. apply ground to Q1.
   c. open P_{t2} ports.
   d. close P_{t7} ports.

6. When engine speed increases, P_{t7} pressure will increase. This will cause

   a. the fulcrum to move to the right.
   b. Q1 to have forward bias.
   c. Q2 conducts current flow.
   d. P_{t7} pressure expands lower bellows.

Answers to Frame 12: 1. two 2. beam 3. grounded

Frame 14

Reference schematic diagram, figure 15, to answer questions on frames 14 through 19.

The voltage requirement for the operation of this system is 115V AC 400-hertz, single-phase AC. This voltage is applied to the primary of the T1 transformer. The primary of this transformer is tapped and 26V AC is picked OFF to power the rotors of the synchros of the transducer and the indicator. The B1 and B2 synchros are located in the transducer.

Circle the letter preceding the correct response.

1. T1 transformer has

   a. 37-volts DC applied to it.
   b. 26V AC, 400-Hz, single-phase AC applied to it.
   c. 115V AC, 400-Hz, single-phase AC applied to it.

Answers to Frame 13: 1. switches 2. transmitters 3. transducer and indicator 4. reverse, motor, nulls (re-center) 5. a 6. c

Frame 15

See figure 15.

The secondary of T1 transformer steps the 115V AC down to 37V AC. The FOUR rectifiers are used to rectify the AC to DC for the operation of the motor and transistors.

Circle the letter preceding the correct response.

1. The FOUR rectifiers are connected to terminals

   a. 4 and 5 of the secondary.
   b. 5 and 6 of the secondary.
   c. 4 and 6 of the secondary.

Answers to Frame 14: 1. c

Frame 16

See figure 15.

The transistors act as electronic switches. They have a reverse bias voltage applied to the base. As long as this reverse bias voltage is applied to the base, the transistors will NOT conduct and act as an OPEN switch. When the beam contacts CLOSE, a ground is applied to the base of the transistor and forward bias is applied to that transistor. This will allow the transistor to conduct.

Circle the letter preceding the correct response.

1. When the top beam contact is closed, transistor
    a. Q1 will conduct because reverse bias is applied to the base.
    b. Q2 will conduct because reverse bias is applied to the base.
    c. Q2 will conduct because forward bias is applied to the base.
    d. Q1 will conduct because forward bias is applied to the base.

Answer to Frame 15: 1. c

841

Frame 17

See figure 15.

There is a set of limit switches, S1 and S2, mounted so that as the moveable fulcrum reaches its limit of travel, it will OPEN one of these switches opening the circuit. This causes the motor to STOP running. These switches are to prevent overtravel and jamming of the fulcrum.

Circle the letter preceding the correct response.

1. When switch S1 opens, it will break the ground to

    a. Q2 transistor.
    b. Q1 transistor.
    c. the DC motor.

2. The units that prevent fulcrum overtravel are

    a. the beam contacts.
    b. S1 and S2 switches.
    c. Q1 and Q2 transistors.
    d. B1 and B2 synchros.

862

Answer to Frame 16: 1. c

Frame 18

See figure 15.

The high speed and low speed transmitter synchros are mechanically connected to the DC motor through a gear train. The DC motor drives these TWO synchros and they, in turn, will send a signal to the TWO synchros in the indicator. The indicator will then show an increase or decrease in EPR depending on which way the motor turns.

Circle the letter preceding the correct response.

1. The B1 synchro is the

    a. high speed synchro in the indicator.
    b. low speed synchro in the transducer.
    c. high speed synchro in the transducer.
    d. low speed synchro in the indicator.

Answers to Frame 17: 1. a 2. b

Frame 19

See figure 15.

The EPR system during operation can cause unusual indications on the indicator. If P_{t2} line becomes OPEN with aircraft on the ground, the indicator will read the same and show an increase during flight.

If P_{t7} line becomes OPEN with aircraft on the ground, indicator will read LOW, and also during flight.

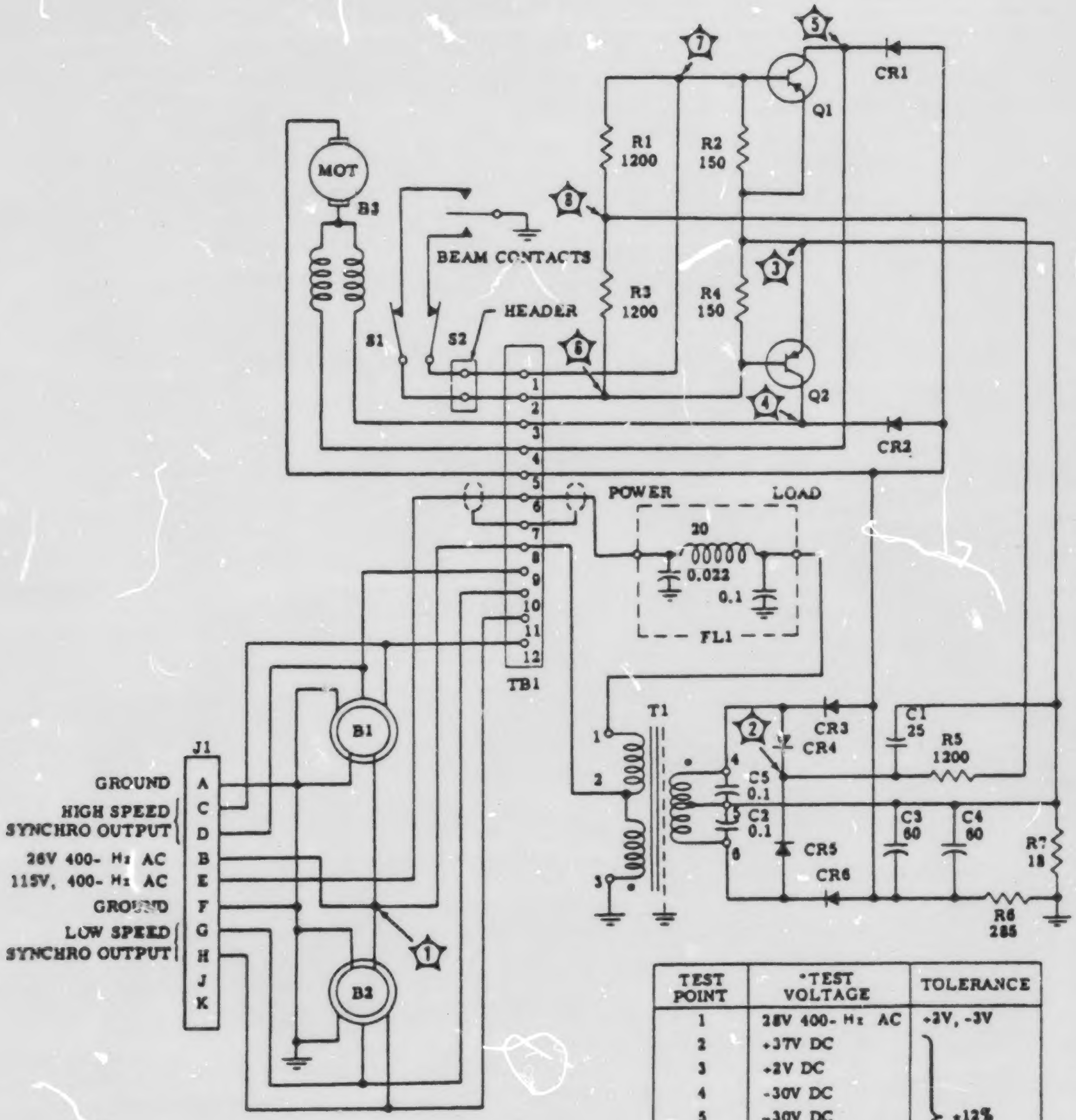
Circle the letter preceding the correct response.

1. When a leak occurs in the P_{t2} line, the indication will be
    a. normal on the ground and high in the air.
    b. normal on the ground and low in the air.
    c. low on the ground and low in the air.
    d. low on the ground and high in the air.

2. When a leak occurs in the P_{t7} line, the indication will be
    a. high EPR indication.
    b. erratic EPR indication.
    c. low EPR indication.
    d. normal EPR indication.

Answer to Frame 18: 1. c

844


MOT
B3
R1 1200
R2 150
R3 1200
R4 150
Q1
Q2
CR1
CR2
BEAM CONTACTS
HEADER
S1
S2
1
2
3
4
5
6
7
8
9
10
11
12
TB1
POWER
LOAD
20
0.022
0.1
FL1
T1
1
2
3
4
5
6
C5 0.1
C2 0.1
CR3
CR4
CR5
CR6
C1 25
R5 1200
C3 60
C4 60
R7 18
R6 285
B1
B2
J1
GROUND
HIGH SPEED SYNCHRO OUTPUT
28V 400- Hz AC
115V, 400- Hz AC
GROUND
LOW SPEED SYNCHRO OUTPUT
A
C
D
B
E
F
G
H
J
K

TEST POINT	*TEST VOLTAGE	TOLERANCE
1	28V 400- Hz AC	+2V, -3V
2	+37V DC	±12%
3	+2V DC	
4	-30V DC	
5	-30V DC	
6	+3.5V DC	
7	+3.5V DC	
8	+15V DC	

*ALL TEST VOLTAGES MUST BE MEASURED WITH RESPECT TO GROUND. DO NOT MEASURE VOLTAGES OTHER THAN THOSE INDICATED.

NOTES: VALUES IN OHMS, MICROFARADS, AND MILLIHENRIES.

• DENOTES RELATIVE ORIENTATION OF WINDINGS.

☆ TEST POINTS

Figure 15.

Answers to Frame 19: 1. a 2. c

865

WORKBOOK
3ABR32531-WB-206
3ABR32632B-WB-306

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

ENGINE PRESSURE RATIO SYSTEM

1 September 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

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DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-206
3ABR32632B-WB-306

INSPECTION, OPERATIONAL CHECK, TROUBLESHOOT AND BENCH CHECK THE ENGINE PRESSURE RATIO SYSTEM

OBJECTIVES

Given a workbook, tools, test equipment, and trainer, perform an inspection and operational check of an engine pressure ratio system with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainer, troubleshoot the engine pressure ratio system with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainer, bench check components of an engine pressure ratio system with an accuracy of 100% correct workbook responses.

EQUIPMENT

	Basis of Issue
3ABR32531-WB-206/3ABR32632B-WB-306	1/student
Tester, Pneumatic Part #268000	1/student
Trainer, Engine Instrument #2951	1/student
Multimeter	1/student
Synchro Instrument Field Test Set (EPR Indicator)	1/student
TO 1B-52B-2-6 EXTRACT	1/student
TO 5P3-4-32-3 EXTRACT	1/student
TO 33D2-6-85-41 EXTRACT	1/student
Wrench (3/8 X 9/16)	1/student

PROCEDURE

Remove ALL JEWELRY when working with electrical equipment. Observe ALL safety precautions. Follow the instructions in the TO EXTRACTS and the workbook to prevent damaging the trainer or test equipment. The TO EXTRACTS are attached to the BACK of this workbook. Place a checkmark (✓) on the proper blanks.

Note: Obtain ALL necessary equipment BEFORE starting lab.

Part 1. INSPECTION

1. Visually inspect the transducer for:	SAT	UNSAT
a. Worn or broken shock mounts.	______	______
b. Dented or broken case.	______	______

Supersedes 3ABR32531-WB-211, 13 January 1975, which may be used until existing stocks are exhausted.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 300; TTVSR - 1 2

c. Damaged electrical connector _____ _____

d. Security of mounting. _____ _____

2. Visually inspect the EPR indicator for:

a. Cracked or loose glass. _____ _____

b. Condition of fluorescent markings. _____ _____

c. Condition of pointers. _____ _____

d. Dented or cracked case. _____ _____

e. Damaged electrical connector. _____ _____

f. Security of mounting. _____ _____

3. Visually inspect the electrical wiring for:

a. Frayed or broken wire. _____ _____

b. Damaged connector plugs. _____ _____

c. Scorched, frayed, or broken insulation. _____ _____

d. Security of mounting. _____ _____

e. Trouble switches in "OUT" position. _____ _____

Part 2. OPERATIONAL CHECK

1. Refer to the EXTRACT from TO 33D2-6-85-41, section II, paragraph 2-7 through 2-9a and b for the Operation of the Tester.

a. The LEAK check is satisfactory _____, unsatisfactory _____.

Note: Using the hose in tester, connect it to the exhaust port of the transducer. Use the pressure system ONLY; PUMP UP pressure as NEEDED while performing the following checks.

2. Perform the operational check on the EPR system using the EXTRACT from TO 1B-52B-2-6, paragraph 3-80, steps 4 through 14.

Note: While performing steps 7 through 14, TAP EPR indicator lightly to remove friction error in indicator.

a. The EPR indicator test in step 7 is sat _____, unsat _____, Indicator Reading _______.

b. The EPR indicator test in step 8 is sat _____, unsat _____, Indicator Reading _______.

c. The EPR indicator test in step 9 is sat _____, unsat _____, Indicator Reading _______.

d. The EPR indicator test in step 10 is sat _____, unsat _____, Indicator Reading ________.

e. The EPR indicator test in step 11 is sat _____, unsat _____, Indicator Reading ________.

f. The EPR indicator test in step 12 is sat _____, unsat _____, Indicator Reading ________.

g. The EPR indicator test in step 13 is sat _____, unsat _____, Indicator Reading ________.

h. The EPR indicator test in step 14 is sat _____, unsat _____, Indicator Reading ________.

Part 3. TROUBLESHOOTING

1. Pump UP pressure to 40 psi.

2. Place trouble switch #1 to the IN position.

a. OPEN PT 7 pressure valve and observe the indication on the EPR indicator while indicator is going upscale, then CLOSE the valve.

b. Main pointer indication is erratic _____ inoperative _____ normal _____.

c. Vernier pointer indication is erratic _____ inoperative _____ normal _____.

3. Place trouble switch #1 to the OUT position and place trouble switch #2 to the IN position.

a. Using valve #3, bleed the pressure OFF and NOTE the indication on the EPR indicator, while the indicator is GOING downscale.

b. Main pointer indication is erratic _____ inoperative _____ normal _____.

c. Vernier pointer indication is erratic _____ inoperative _____ normal _____.

4. Place trouble switch #2 to the OUT position.

5. OPEN valves 1 through 5 and bleed down pressure in tester.

6. Disconnect tester, stow the hose and close the tester. Return wrench to the tool box.

7. Turn OFF the power switch, pull the circuit breaker and disconnect the trainer from the power source.

8. Connect test leads to multimeter and ZERO the multimeter.

9. Disconnect the electrical connector plugs from the indicator and transducer.

10. Place trouble switch #1 to the IN position. Fill in the correct wire number on the blank provided and indicate the type of trouble (open, short, etc).

a. Wire number ________________.

b. The trouble is ______________.

11. Place trouble switch #1 to the OUT position and place trouble switch #2 to the IN position. Fill in the correct wire number on the blank provided and indicate the type of trouble (open, short, etc).

a. Wire number ________________.

b. The trouble is ______________.

12. Place trouble switch #2 to the OUT position.

13. Reconnect the electrical connector plugs to the indicator and transducer (32632B ONLY).

14. On the multimeter, turn function switch to DC volts and turn the range switch ALL the way to the right (Safety L).

15. Disconnect leads from multimeter and return the leads and multimeter to the cabinet.

Part 4. BENCH CHECK INDICATOR

Note: For 3ABR32531 STUDENTS ONLY.

1. Set ALL switches and controls to OFF or fully counterclockwise position on the synchro field tester.

2. Connect power cable "A" (QB86030-1) to power input connector #10 on test unit. Connect the other end of this cable to 115V AC, 400 Hz output plug.

Note: Make sure power switch #17 on the tester is in the OFF position.

3. Connect cable "G" (#QB86030-1) to test unit connector #9 on tester.

4. Connect cable "J" (#QB84998-1) to cable "G" (#QB86030-1).

5. Remove EPR indicator from trainer.

6. Connect DUAL cable "K" (plastic covered) to indicator.

7. Connect cable "J" (#QB849998-1) to DUAL cable marked low speed synchro.

8. Turn adjuster knob on tester trans. #1 to ZERO degrees.

9. Place SYN IND knob #4 to CAL position and switch #2 to SYN IND position.

10. Place switch #17 to ON position. Power lamp #16 should GLOW, indicating tester is ON.

11. Refer to the EXTRACT from TO 5P3-4-32-3, paragraph 11e and f, to perform the scale error, friction error and position error tests on the main dial.

12. Test the indicator for scale error by positioning the calibrator (trans. #1) at the setting shown in the CHART below. Place a checkmark (✓) and response in the proper columns.

13. Test the indicator for position error by rotating the indicator about its axis on a plane 90 degrees from the NORMAL position. Indications must remain within tolerances indicated in CHART below. Also perform the friction error check.

14. Perform friction, scale and position error at the same time.

Note: If not correct, adjust trans. #1 until indicator reads EXACT engine pressure ratio units as shown on the CHART BELOW.

Trans #1 Setting Degrees	Exact Degrees	Press Ratio Units On Indicator	Tolerances			Friction Error		Scale Error	
			Degrees	Before Tap	After Tap	S	U	S	U
51.0		1.20	1.20						
87.8		1.50	1.20						
124.6		1.80	1.20						
149.1		2.00	1.20						
173.7		2.20	1.20						
180.0*		2.25							
186.0		2.30	1.20						
198.3		2.40	1.20						
222.8		2.60	1.20						
271.9		3.00	1.20						
321.0		3.40	1.20						

* Electrical Zero

851

a. Friction error test is satisfactory _____ unsatisfactory _____.

b. Scale error test is satisfactory _____ unsatisfactory _____.

c. Position error test is satisfactory _____ unsatisfactory _____.

d. Electrical zero check is satisfactory _____ unsatisfactory _____.

15. Place power switch #17 to OFF position.

16. Disconnect low speed synchro test CABLE "K" from CABLE "J" (#QB84998-1), and connect high speed synchro test CABLE "K" to CABLE "J" (#QB84998-1).

17. Turn adjustment knob on tester trans. #1 to ZERO degrees.

18. Place power switch #17 to ON position.

19. Refer to the EXTRACT from TO 5P3-4-32-3, paragraph 11e and f, to perform the scale error, friction error and position error tests on the SUB dial.

20. Test the indicator for scale error by positioning the calibrator (trans #1) at the setting shown in the CHART below. Place a checkmark (✓) and response in the proper columns.

21. Test the indicator for position error by rotating the indicator about its axis on a plane 90 degrees from the NORMAL position. Indications must remain within tolerances indicated in CHART below. Also perform the friction error check.

22. Perform friction, scale and position error at the same time.

Note: If not correct, adjust trans. #1 until indicator reads EXACT engine pressure ratio units as shown on the CHART BELOW.

Trans #1 Setting Degrees	Exact Degrees	Press Ratio Units On Indicator	Tolerances Degrees	Before Tap	After Tap	Friction Error S	Friction Error U	Scale Error S	Scale Error U
68.0		0.02	3.6						
140.0		0.04	3.6						
184.0*		0.053							
212.0		0.06	3.6						
284.0		0.08	3.6						
356.0		0.10	3.6						

* Electrical Zero

a. Friction error test is satisfactory _____ unsatisfactory _____.

b. Scale error test is satisfactory _____ unsatisfactory _____.

c. Position error test is satisfactory _____ unsatisfactory _____.

d. Electrical zero check is satisfactory _____ unsatisfactory _____.

23. Turn adjuster knob (trans. #1) to ZERO degrees.

24. Place power switch #17 to OFF position.

25. Disconnect DUAL test cable from indicator.

26. Place indicator back in trainer and reconnect indicator and transducer trainer to electrical connector plugs.

27. Disconnect power CABLE "A" (#QB86962-1) from 115V AC 400 Hz outlet.

28. Disconnect power CABLE "A" (#QB86062-1) from tester and stow cable in tester.

29. Disconnect high speed synchro CABLE "K" from test CABLE "J" (#QB84998-1) and stow DUAL cable in tester.

30. Disconnect test CABLE "J" (#QB84998-1) from test CABLE "G" (#QB86030-1) and stow cable in tester.

31. Disconnect test CABLE "G" (#QB86030-1) from tester and stow in tester.

32. Close lid on tester and put tester back on shelf.

33. Turn workbook into instructor.

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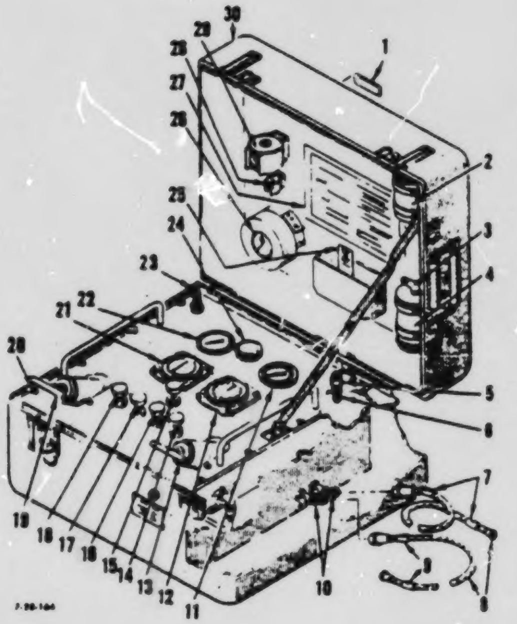
SECTION II
OPERATION AND SERVICE INSTRUCTIONS

2-1. CONTROLS, INDICATORS, AND CONNECTIONS.

2-2. Operation of this tester requires complete familiarity with all components of the tester. (See figure 2-1.) See figure 2-2 for a list of controls, indicators, and connections incorporated in this tester, and description of their function. In addition, see figure 2-3 for plumbing arrangement used in this tester for each of two test setups. Provisions are included in this tester for connection to external pressure and vacuum sources as an optional method of supplying these requirements. (See figure 2-4.) Pressure and vacuum gages are provided for indicating either externally procured or manually obtained pressures and vacuums.



1. *Plate*
2. *Machmeter*
3. *Elbow*
4. *Gage*
5. *Cap Assy*
6. *Union*
7. *Nameplate*
8. *Hose Assy*
9. *Nameplate*
10. *Elbow*
11. *Gage*
12. *Gage*
13. *Pumping Assy*
14. *Valve*
15. *Valve*
16. *Valve*
17. *Valve*
18. *Valve*
19. *Pumping Assy*
20. *Screw*
21. *Machmeter*
22. *Gage*
23. *Socket*
24. *Regulator*
25. *Card*
26. *Watch*
27. *Plate*
28. *Coupling Assy*
29. *Coupling Assy*
30. *Case Assy*

Figure 2-1. Pressure Ratio Transducer Tester Components

CAUTION

The machmeters (2, 21, figure 2-1), absolute pressure gages (4, 12), vacuum gage (11), and pressure gage (22) are delicate instruments and must be handled with extreme care at all times.

2-3. PREPARATION FOR USE. (See figure 2-1.)

2-4. GENERAL.

a. Remove screws (37, figure 3-1) and lift out gages (35, 36) with pneumatic lines attached. Remove hose assemblies (7, 8, 9, figure 2-4) or remove screws (20, figure 2-1), and carefully lift out panel of case assembly (30) to permit access to interior of tester.

b. See figure 2-3 for schematic of alternate plumbing arrangement used in operating tester. Setup No. 1 shows the installation of machmeter (21, figure 2-1) and absolute pressure gage (12) used to perform operational test. Setup No. 2, figure 2-3, shows installation of two absolute pressure gages (4, 12, figure 2-1) used to obtain pressure ratios to conform with engine pressure ratio transducer valves.

2-5. INSTALLATION OF ALTERNATE SETUP.

2-6. SETUP NO. 2. Prepare setup as follows:

a. Remove gage (4, figure 2-1) stored in cover of case assembly (30) for use in place of machmeter (21).

b. Disconnect hose assemblies (8, 9, figure 2-4) from machmeter and one hose assembly (7) from absolute pressure gage (12, figure 2-1) to P_{T2}.

c. Connect one hose assembly (8, figure 2-4) to absolute pressure gage (4, figure 2-1), and one hose assembly (8, figure 2-4) from absolute pressure gage (4, figure 2-1) to P_{T2}.

d. Install cap (36, figure 2-4) on absolute pressure gage tee (30).

Index No. (figure 2-1)	*Description*	*Panel Marking*	*Function*
4, 12	Gage		Indicates absolute pressure (0 to 100 in. Hg abs).
6	Union	VACUUM EXTERNAL	Hose assembly connection for external vacuum line.
8	Hose Assy		Used to connect P_{T2} inlet system of unit under test.
8	Hose Assy		Used to connect to P_{T7} exhaust system of unit under test.
10	Elbow	P_{T2}	Provides connection to inlet of unit under test.
10	Elbow	P_{T7}	Provides connection to exhaust of unit under test.
15	Valve No. 5	CROSSBLEED	Equalizes pressure between P_{T2} and P_{T7} when used for vacuum at altitude.
11	Gage	VACUUM SOURCE (in. Hg)	Indicates vacuum (0 to 30 in. Hg).
2, 21	Machmeter		Indicates mach (0.5 to 1.5) in units of pressure ratio.
13	Pumping Assy	VACUUM PUMP	Used for manual evacuation.
14	Valve No. 4	P_{T7} PRESSURE	Regulates exhaust pressure to unit under test.
16	Valve No. 3	P_{T7} BLEED	Regulates exhaust bleed to unit under test.
17	Valve No. 2	P_{T2} BLEED	Regulates vacuum bleed to unit under test.
18	Valve No. 1	P_{T2} VACUUM	Regulates inlet vacuum to unit under test.
19	Pumping Assy	PRESSURE PUMP	Used for manual pressurization.
22	Gage	PRESSURE SOURCE PSIG	Indicates pressure (0 to 60 psig) (downstream of external source pressure regulator).
23	Socket	PRESSURE EXTERNAL	Hose assembly connection for optional external pressure.
24	Regulator	PRESSURE REGULATOR EXTERNAL SOURCE	Regulates pressure of external pressure source.
26	*Stop Watch		Used for accurate timing of pressure and vacuum decay rates.
28	Coupling Assy		Used to attach P_{T2} hose assembly to pitot head.
29	Coupling Assy *Stop watch Part No. 111 no longer furnished as part of test set. Item will be requisitioned from appropriate supply class on an as required basis.		Used to attach P_{T2} hose assembly to pitot head.

Figure 2-2. Controls, Indicators, and Connections

e. Connect loose end of hose assembly (9) to absolute pressure gage (12, figure 2-1).

2-7. OPERATION.

2-8. PRELIMINARY TEST. (See figure 2-1.)

Note

Tap all gages lightly with fingers before taking readings.

2-9. Test pressure ratio transducer tester assembly each day before using as follows.

a. Place all controls in the off or neutral position. Note that all metering valves are placed in full clockwise position.

CAUTION

The metering valves (14 thru 17) are sensitive and should be closed without undue force or damage may result.

b. Pressurize tester to 40 psi by means of pumping assembly (19). Note that there is no leakage by observing pressure gage (22).

c. Evacuate tester to 25.0 inches of mercury by means of pumping assembly (13). Note that there is no leakage by observing vacuum gage (11).

Note

Apply one drop of lubricating oil (Specification MIL-L-6086) daily on each piston rod of pumping assemblies before using.

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855

3-60. PROCEDURE FOR TESTER P/N 268000 (TEST SETUP 1).

STEP	RESULT
1. Raise engine upper side cowl panel so that exhaust pressure connector is accessible (3 and 5, figure 3-19).	
2. Check that exhaust pressure drain tubes are sealed shut either with caps or with valves.	
3. Disconnect exhaust pressure line either at connection to probe (or probe manifold) or at flexible line.	
3A. Check that tester plumbing conforms to TEST SETUP 1 shown in figure 3-19A. (Refer to T. O. 33D2-6-85-41 for additional tester information.)	

NOTE

Check that tester absolute pressure gages and machmeter are calibrated per T. O. 33D2-6-85-41.

STEP	RESULT
4. Connect pressure line (P_{T7}) of portable transducer test set to connector selected in step "3." Tester P_{T2} line must remain open to atmosphere.	
5. Check that external electrical power is connected.	
6. Close ENG PRESSURE RATIO IND circuit breakers on pilot's auxiliary circuit breaker panel.	

CAUTION

Do not exceed 95.00 inches of mercury absolute (47 psi absolute) on the exhaust pressure line. Maximum differential between the two pressures must not exceed 70 inches of mercury absolute (34 psi absolute) at any time. Permanent damage to the transducer may result.

STEP	RESULT
6A. Check that tester VALVES 1 thru 5 are closed.	
6B. If tester pressure pump is not used, connect external pressure source and adjust pressure regulator to maintain a pressure of not more than 47 psia.	

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876

STEP	RESULT
7. Using valve 4 (P_{T7} PRESSURE), raise pressure until machmeter reads 0.8.	EPR indicator on pilots' instrument panel should read 1.52 (±0.030).

NOTE

Valve 5 (CROSSBLEED) may be used in conjunction with P_{T7} PRESSURE valve to obtain desired machmeter reading.

STEP	RESULT
8. Raise pressure until machmeter reads 1.0.	EPR indicator should read 1.89 (±0.030).
9. Raise pressure until machmeter reads 1.2.	EPR indicator should read 2.41 (±0.030).
10. Raise pressure until machmeter reads 1.3.	EPR indicator should read 2.71 (±0.030).
11. Raise pressure until machmeter reads 1.4.	EPR indicator should read 3.05 (±0.030).
12. With indicator reading any value above 1.20, open ENG PRESSURE RATIO IND circuit breaker for engine under test.	Indicator reading should not change while circuit breaker is open.
13. With circuit breaker still open, change test pressures.	Indicator reading should not change.
14. Close circuit breaker.	Indicator pointer should move to new pressure ratio within 0.1.

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and case (5) for approximately five seconds. There must be no indication of insulation breakdown.

n. Apply one drop of lubricating oil (Military Specification MIL-L-6085) to teeth of gears (21, 28), then install spacer ring (3) and case (5). Install retaining ring (2).

o. Do not install tube in connector (16), solder retaining ring (2) in place, or solder nameplate (1) on connector until unit has been calibrated in accordance with paragraph 11.

p. Insert end of soft copper tubing, supplied in kit, ¼-inch deep into small hole in connector (16); solder tube in place. Perform test procedure outlined in paragraphs 11*a* thru 11*f*, then solder completely around retaining ring (2), using minimum amount of solder (Federal Specification QQ-S-571, Type Sn60-W-AR-P2) needed to obtain a hermetic seal.

q. Install nameplate (1) and secure with a drop of solder (Federal Specification QQ-S-571, Type Sn60-W-AR-P2) on each pin.

r. Thoroughly dry interior of assembled unit by baking at 150°F to 160°F (65.5°C to 71°C) for five to six hours, then connecting filling tube of connector (16) to a vacuum pump and reducing pressure inside unit to 10 microns of mercury absolute for a minimum of 10 hours.

s. Pressurize unit to 15 to 18 psi absolute with helium of at least 98 percent purity, free of dust particles, and containing not more than 0.006 milligram of water vapor per liter at filling pressure. Crimp filling tube tightly in three or four locations at outer end of tube and solder over hole in end of tube using solder (Federal Specification QQ-S-571, Type Sn60-W-AR-P2). Perform leakage test and moisture content test as outlined in paragraphs 11*g* and 11*h*, before final crimping, cutting, and soldering of filling tube is accomplished.

t. After unit has satisfactorily passed leakage and moisture content test, crimp filling tube as close as possible to flange of connector (16); cut and flatten tube, then solder to flange, using solder (Federal Specification QQ-S-571, Type Sn60-W-AR-P2). Tube must not extend more than 0.045 inch beyond rear of case.

u. To refinish painted areas, mask off glass (4), connector (16) and all of soldered end of unit. Then apply one coat primer (E42GP11, Sherwin-Williams, Cleveland, Ohio, or equivalent; no known Government specification) and allow to air dry a minimum of two hours. When primer is dry, apply one coat black lacquer (Specification MIL-L-6805)(AER), (Color No. 604) and allow to air dry minimum of four hours.

11. TEST PROCEDURE.

a. *Perform calibration test as follows:* Connect indicator to 7CAC-802125 Calibrator.

b. Adjust calibrator for main-dial electrical zero calibration test. With indicator energized, main dial pointer on indicator must point to electrical zero mark on indicator dial (2.25 pressure ratio mark).

c. Adjust calibrator for sub-dial electrical zero calibration test and check that sub-dial pointer on indicator points to electrical zero mark on indicator dial (0.052 pressure ratio mark).

d. Energize phase test circuit of calibrator until sub-dial pointer comes to rest; pointer must stop at a position approximately 180 degrees from electrical zero. De-energize phase-test circuit; pointer must return to electrical zero and must not oscillate more than 15 seconds before coming to a full stop. Repeat test for main-dial pointer.

e. Test the indicator for scale error by positioning the calibrator pointer at settings shown in figure 5. Pressure ratio indicator unit indications and tolerances must be as shown in figure 5.

Calibrator Setting in Degrees	*Pressure Ratio Units on Indicator*	*Tolerance*	
		Pressure Ratio Units	*Degrees*
	MAIN DIAL		
51.0	1.20	0.01	1.20
87.8	1.50	0.01	1.20
124.6	1.80	0.01	1.20
149.1	2.00	0.01	1.20
173.7	2.20	0.01	1.20
180.0*	2.25		
186.0	2.30	0.01	1.20
198.3	2.40	0.01	1.20
222.8	2.60	0.01	1.20
271.9	3.00	0.01	1.20
321.[illegible]	3.40	0.01	1.20
	SUB DIAL		
68.0	0.02	0.001	3.6
140.0	0.04	0.001	3.6
184.0*	0.053		
212.0	0.06	0.001	3.6
284.0	0.08	0.001	3.6
356.0	0.10	0.001	3.6

*Electrical zero.

Figure 5. Scale Error Test Data

f. *Perform friction error and position error tests as follows:* Repeat tests as outlined in figure 5, but rotate indicator about its axis on a plane 90 degrees from normal position to test for position error. Indications must remain within tolerances given in figure 5. To test for friction error, tap outside of indicator case after pointers come to rest. Indications before and after tapping must remain within tolerances indicated in figure 5. Disconnect indicator from calibrator.

g. *Perform leakage test as follows:* Place indicator in 7CAL-270900 Glass Jar Desiccator containing distilled water with approximately 0.1 percent by weight of wetting agent (Aerosol OT, 75% Aqueous, American Cyanamid Co, Plastic and Resins Div, New York, New York, or equivalent; no known Government specification) at a maximum temperature of 100°F (37.8°C). Evacuate desiccator to 2.5 inches of mercury absolute, maintaining a maximum ambient temperature of 100°F (37.8°C) surrounding the desiccator. There must be no bubbles coming from within indicator. Remove indicator from desiccator and dry thoroughly.

h. *Perform moisture content test as follows:* Place indicator in front of a testing device capable of delivering a blast of air at 0°F (−17.8°C) on face of indicator cover glass. Hold indicator in air blast until outside of glass is completely frosted. Remove indicator and clean accumulated frost from front of cover glass. There must be no indication of frost or dew forming on inside of cover glass.

i. *Perform dielectric test as follows:* Repeat dielectric breakdown test outlined in paragraph 10m.

j. See figure 6 for trouble shooting information.

TROUBLE	PROBABLE CAUSE	REMEDY
Pointer fails to move to electrical zero during calibration.	Pointer loose in shaft.	Remove pointer, re-cement, and replace.
	Synchro defective.	Replace defective synchro.
Pointer oscillation exceeds 15-second time limit in phase test.	Synchro defective.	Replace defective synchro.
Pointer fails to return to electrical zero when phase test circuit is de-energized.	Defective synchro, binding gears, or defective bearings.	Replace synchro. Clean or replace gears. Replace bearings.
Pointer moves but is out of calibration with pressure ratio points.	Synchro defective.	Replace defective synchro.
	Bearings defective.	Check bearings for roughness and freedom of movement. Replace defective bearings.
Dew forms on inside of glass cover when checked for moisture content.	Moisture inside indicator case.	Cut crimped portion of filling tube allowing helium to escape. Repeat procedure for drying, filling, and sealing unit.
Indicator leaks around cover glass during leakage test.	Tinning defective in soldering area of case.	Disassemble, re-tin case, and replace cover glass.
Indicator leaks around filling tube or retaining ring.	Solder not bonding.	Resolder leaking area. Cut crimped portion of filling tube, allowing helium to escape. Repeat procedure for drying, filling, and sealing unit.

Figure 6. Trouble Shooting Information

Note

Important. This publication reflects the use of repair kits intended to provide the user with most replacement parts usable at major overhaul, and at minor repair. Certain replacement parts are stocked only in kits. Those procurable parts not in kits are stocked in their appropriate class. Standard parts, and parts having multi-application, are stocked in their appropriate class, and may also be stocked in kits. *Do not order kit parts from separate stock to serve a kit purpose.* Refer to column in breakdown titled Source Code, and to applicable Source Code Definitions that follow parts list.

Fig. and Index No.	*Part No.*	*1 2 3 4 5 6 7* *Description*	*Units per Assy*	*Usable on Code*	*Source Code*

ENGINE PRESSURE RATIO INDICATORS PART NO. 45716 AND 45716-1

Code: "A" designates parts used only in Indicator Part No. 45716 (Model No. PR11-1-2).
"B" designates parts used only in Indicator Part No. 45716 (Model No. PR11-1-3).
"C" designates parts used only in Indicator Part No. 45716-1 (Model No. PR11-2-1).

Fig. and Index No.	Part No.	1 2 3 4 5 6 7 Description	Units per Assy	Usable on Code	Source Code
7	45716	INDICATOR, ENGINE PRESSURE RATIO (instl outline) (Federal Stock No. 6620-828-8090)	1	A,B	
	45716-1	INDICATOR, ENGINE PRESSURE RATIO (instl outline)	1	C	
7	45717	. INDICATOR ASSY, PRESSURE RATIO	1	A,B	U
	45717-1	. INDICATOR ASSY, PRESSURE RATIO	1	C	U
-1	88864-2	. . NAMEPLATE, PRESSURE RATIO INDICATOR	1	A,B	KD
	88400-4	. . NAMEPLATE, PRESSURE RATIO INDICATOR	1	C	KD

PROGRAMMED TEXT
3ABR32531-PT-207

Technical Training

Avionic Instrument Systems Specialist

RESISTANCE-TYPE LIQUID QUANTITY SYSTEM

18 July 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.
Do Not Use on the Job.

FOREWORD

This programmed text was prepared for use in course 3ABR32531 Avionic Instrument Systems Specialist. This text has been validated using 30 students from the subject course. Twenty-nine of the students achieved the objective as stated, average completion time is 26 minutes.

OBJECTIVE

Without references, identify facts pertaining to the purpose, operation, and/or characteristics of the resistance-type liquid quantity indicating system with an accuracy of at least 80%.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading the information in each frame you are asked to actively respond to the statements at the end of that frame. Place your responses on the answer sheet provided with this text. Check your responses for accuracy with the correct responses given at the end of the following frame. If you make an incorrect response, reread the frame until you determine why you were in error before proceeding to the next frame. After completion of the text you will take an appraisal to display your attainment of the stated objective. Work as quickly as possible, but DO NOT RUSH!

Supersedes 3ABR32531-PT-212, 4 October 1973.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC-W - 200; TTVSR - 1

Frame 1

When aircraft were first developed and the design resembled a box-kite, the fuel and oil quantity indicating systems consisted of a dip stick placed into the tank whenever the pilot felt like checking the level. This system worked well as long as the flights were limited to short hops around the local field. As the aircraft increased in size and the flights became longer, there was a definite need for accurately measuring the amount of fuel and oil in the tanks. Several different companies manufactured liquid quantity systems to meet this need. We are going to discuss one particular liquid quantity system in this programmed text.

NO RESPONSE REQUIRED

Frame 2

The resistance-type liquid level system is sometimes refered to as the float-type liquid level indicating system. The components that are required to make up this system are an indicator (figure 1), and a tank unit transmitter (figure 2). These two units are connected by aircraft wiring and operate from a 28 volt DC generator system. The tank unit, shown by figure 2, senses a mechanical movement of the float as the height of the liquid changes. As the float moves up or down, an electrical signal is sent to the indicator which will display the number of gallons of liquid in the tank.

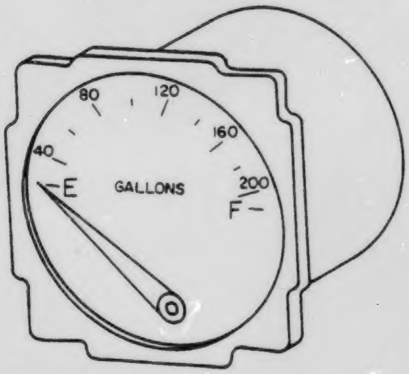

Figure 1

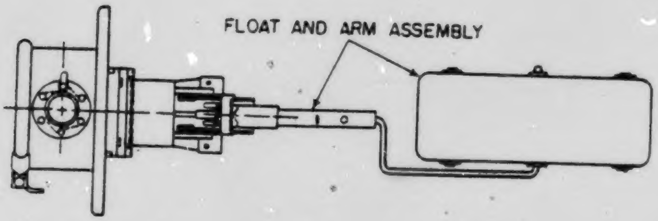

Figure 2

Circle the letter of the correct response to the following statement(s).

1. As the float moves, an electrical signal causes the indicator pointer to indicate

   a. full at all times.
   b. the gallons of liquid in the tank.
   c. empty at all times.
   d. the depth of liquid in the tank.

2. The voltage requirement for the resistance-type liquid level indicating system is

   a. 12 volts DC.
   b. 24 volts DC.
   c. 28 volts DC.
   d. 28 volts AC.

Frame 3

As the level of the liquid decreases, the float and arm assembly moves to a lower level. Figure 3 shows the position of the float and arm assembly in a tank one half full of liquid. Notice the float arm stops. These stops can be adjusted to limit the amount of travel of the float and arm assembly.

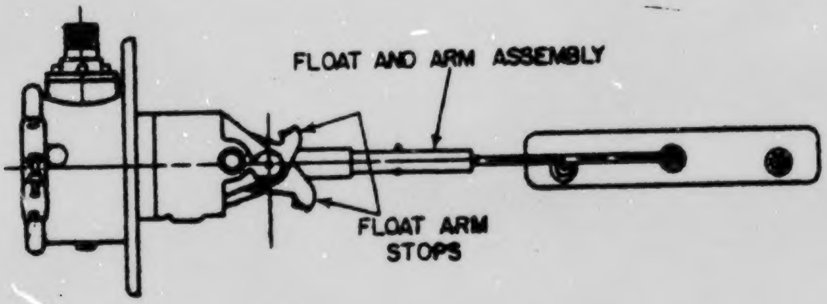

Figure 3

Circle the letter of the correct response to the following statement(s).

1. The liquid level

   a. is controlled by the float arm.
   b. controls the movement of the float arm.
   c. controls the flow of liquid.

Answers to Frame 2: 1. b, 2. c.

Frame 4

Connected to the float and arm assembly is the operating rod, as shown in figures 4 and 5 below. This operating rod is attached to the bellows and seal assembly through the bellows arm. See figure 5. The bellows and seal assembly is used in the transmitter to prevent the liquid from entering the electrical section of the transmitter. With this type of mechanical linkage, whenever the float arm is moved by the level of liquid changing the bellows will expand or contract depending on the direction of the float arm movement.

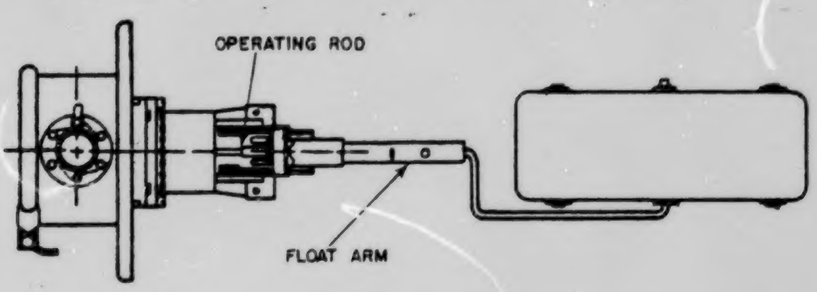

Figure 4

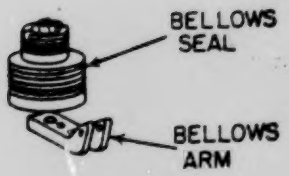

Figure 5

Circle the letter of the correct response to the following statement(s).

1. The movement of the bellows arm

   a. is controlled by the bellows.
   b. moves the bellows.
   c. moves the float arm.

Answer to Frame 3: 1. b

Frame 5

As the bellows expands or contracts the bellows lever (located in the electrical section of the transmitter) is moved back and forth. This bellows lever is attached to the wiper arm of the transmitter potentiometer through mechanical linkage. See figure 6 below. This mechanical linkage (OFFSET LINK and LINK to the WIPER ARM) converts the back and forth movement of the bellows lever to a circular movement of the wiper arm.

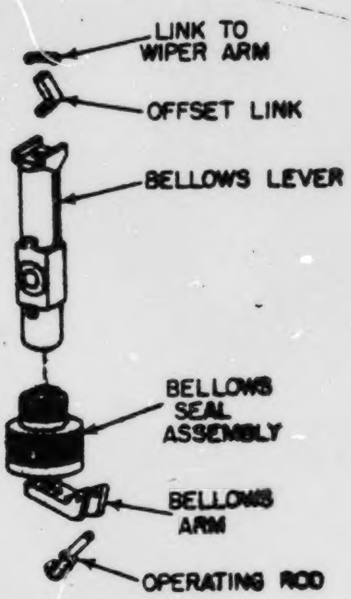
LINK TO WIPER ARM
OFFSET LINK
BELLOWS LEVER
BELLOWS SEAL ASSEMBLY
BELLOWS ARM
OPERATING ROD

Figure 6

Circle the letter of the correct response to the following statement(s).

1. The movement of the bellows lever controls the movement of the

   a. bellows.
   b. wiper arm.
   c. bellows arm.

Answer to Frame 4: 1. b

Frame 6

When the wiper arm of the transmitter potentiometer is rotated along the resistance strip, the resistance value changes. This change in resistance allows a greater or a lesser voltage (depending on the direction) to be applied to the indicator coils.

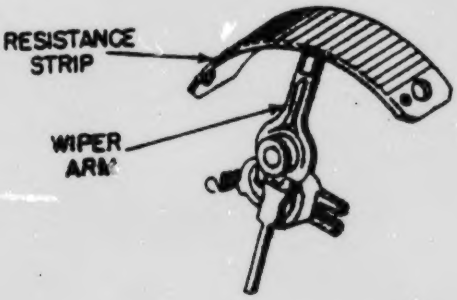

Figure 7

Circle the letter of the correct response to the following statement(s).

1. The voltage applied to the coils of the indicator is controlled by the

    a. float.
    b. float arm.
    c. bellows arm.
    d. wiper arm moving across the resistance strip.

Answer to Frame 5: 1. b

Frame 7

Match the names of the items in Column B to their functions listed in Column A by placing the letter of the correct response in the space provided.

Column A

1. _____ Directly repositions the wiper arm on the resistance strip.
2. _____ Controls voltage to the indicator.
3. _____ Forms a leak proof seal to keep fuel out of the electrical section.
4. _____ Floats on top of liquid and controls operating rod movement.
5. _____ Sends electrical signal to the indicator.

Column B

a. Bellows and seal assembly.
b. Transmitter.
c. Float and arm assembly.
d. Bellows lever, offset link, and link to wiper arm.
e. Potentiometer.

Answer to Frame 6: 1. d

868

Frame 8

The indicators used in a float type system may be a single indicator as shown in figure 8, or a dual indicator similar to the one shown in figure 9. The pointers of either type may travel 65°, 90°, or 120°, depending on the design of the indicator.

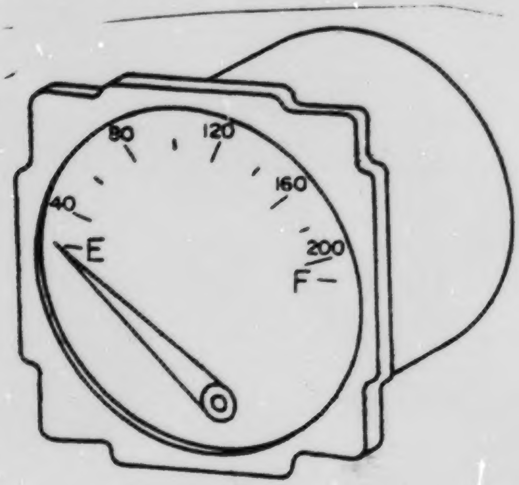
80
120
40
160
E
200
F

Figure 8

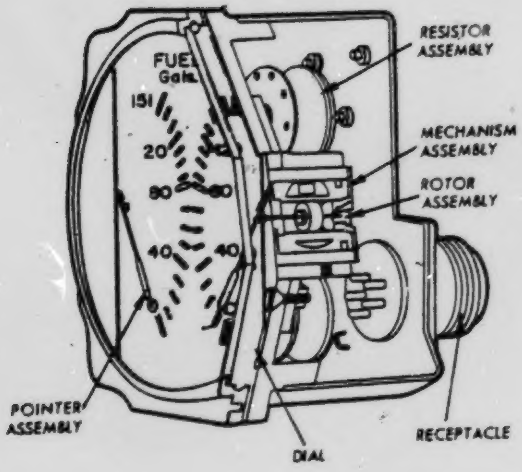
FUEL
Gals
151
20
80
80
40
40
RESISTOR ASSEMBLY
MECHANISM ASSEMBLY
ROTOR ASSEMBLY
POINTER ASSEMBLY
DIAL
RECEPTACLE

Figure 9

NO RESPONSE REQUIRED

Answers to Frame 7: 1. d, 2. e, 3. a, 4. c, 5. b

Frame 9

The indicator is primarily a ratiometer type meter movement with the dial calibrated to read in gallons. It contains the electromechanical mechanism which is connected to the electrical receptacle. See figure 9.

Use figure 9 and circle the letter of the correct response to the following statement(s).

1. The dial of the indicator is calibrated from

   a. 0 to 15.1 gallons.
   b. 0 to 151 gallons.
   c. 0 to 1,510 gallons.
   d. 0 to 15,100 gallons.

2. The dial of the indicator is calibrated to indicate

   a. pints.
   b. quarts.
   c. gallons.
   d. inches.

Frame 10

The ratiometer movement of the indicator has a permanent magnet as a rotor. This movement also includes two stationary coils, called deflection coils, mounted 120° apart. These coils, 1 and 2, are used to deflect the permanent magnet rotor when current flows through them. See figure 10. Included in the indicator is a pull off magnet (1) that is used to pull the pointer to an off scale position when power is removed from the circuit.

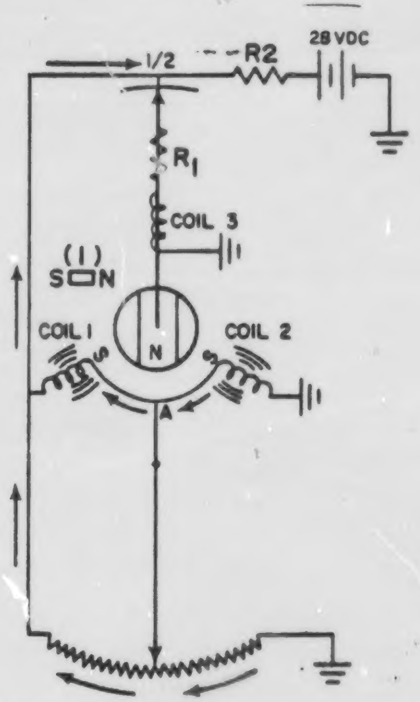

Figure 10

Circle the letter of the correct response to the following statement(s).

1. Coils 1 and 2 are used to
   a. control the current flow in the circuit.
   b. control the strength of coil 3.
   c. deflect the rotor when current flows through them.
2. The pull off magnet is used to
   a. steady the pointer at empty.
   b. steady the pointer at full.
   c. pull the pointer to off scale with power removed.

Answers to Frame 9: 1. b, 2. c.

The third coil is known as the scale length coil 3. You can see this coil in figure 10. It determines the range of the pointer movement. Resistor R1 limits the amount of current flow in coil 3. By limiting the current flow in coil 3, this resistor is actually controlling the magnetic field strength of coil 3. Thus, resistor R1 would be of one value for a 65° range indicator and another value for a 90° range indicator. For a 120° range indicator, coil 3 is wound to change the magnetic polarity of the coil. Resistor R2, shown in figure 10, is used to protect the circuitry from damage due to the deflection coils shorting.

Circle the letter of the correct response to the following statement(s).

1. The range of the pointer movement is controlled by

   a. R1 and coil 1.
   b. R2 and coil 2.
   c. R1 and coil 3.
   d. R2 and coil 3.

2. The R1 resistor is used to control the amount of current flow through the

   a. R2 resistor.
   b. deflection coil 1.
   c. deflection coil 2.
   d. scale length coil 3.

Answers to Frame 10: 1. c, 2. c.

Frame 12

The permanent magnet rotor is mounted inside a copper damping assembly. This assembly dampens rotor movement and prevents excessive pointer oscillation. The pointer is attached directly to the rotor. See figure 11.

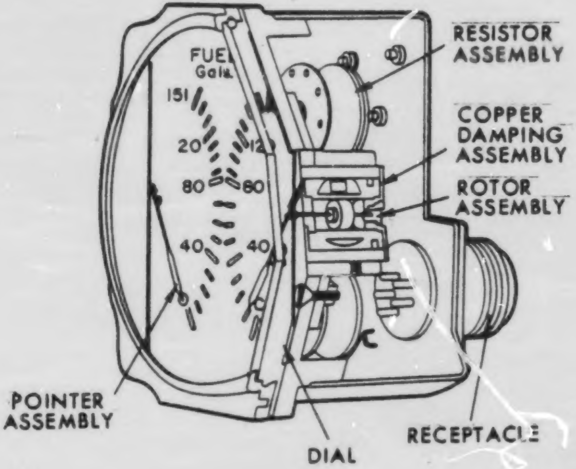
FUEL
Gals
151
20
80
40
12
80
40
RESISTOR ASSEMBLY
COPPER DAMPING ASSEMBLY
ROTOR ASSEMBLY
POINTER ASSEMBLY
DIAL
RECEPTACLE

Figure 11

Circle the letter of the correct response to the following statement(s).

1. The copper damping assembly

   a. aids coil 1.
   b. aids coil 2.
   c. aids the magnetic strength of the rotor.
   d. reduces rotor movement to prevent pointer oscillation.

Answers to Frame 11: 1. c, 2. d.

Frame 13

Match the names of the items in Column B to their functions in Column A by placing the letter of the correct response in the space provided.

Column A	Column B
1. _____ Used to determine the range of the movement.	a. Copper damping assembly.
2. _____ Moves the indicator pointer.	b. Indicator.
3. _____ Indicates amount of liquid in gallons.	c. Deflection coils.
4. _____ Used to produce an electromagnetic field in the indicator.	d. Rotor.
5. _____ Prevent excessive pointer oscillation.	e. Scale length coil and R1 resistor.

Answer to Frame 12: 1. d

Frame 14

The resistance strip of the transmitter will form one leg of a bridge circuit and the two deflection coils form the other leg. The wiper arm is electrically connected to the deflection coils. This wiper arm serves as the bridge and connects the two legs. See figure 12. In the following frames we will discuss three different levels of liquid and how the system operates for each level.

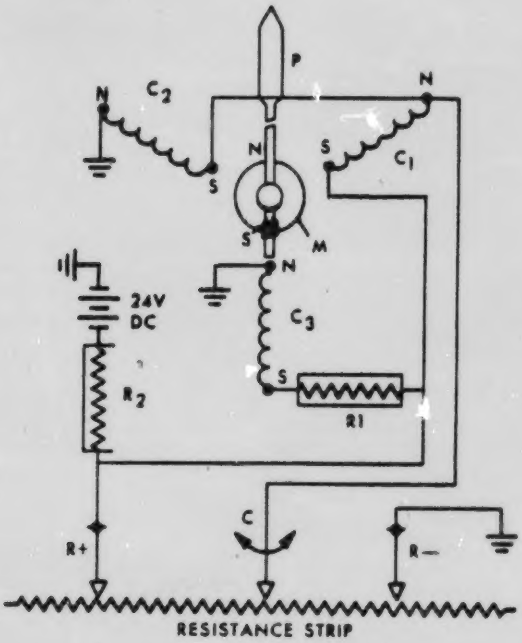
P
N
C_2
N
N
S
S
C_1
S
M
S
N
24V DC
C_3
S
R_2
R1
C
R+
R−
RESISTANCE STRIP

Figure 12

NO RESPONSE REQUIRED

Answers to Frame 13: 1. e, 2. d, 3. b, 4. c, 5. a

Frame 15

The first of the three levels of liquid we will discuss is when the tank is empty. See figure 13 below. With the wiper arm in this position, current will flow through coil 2 along the wiper arm to point B and then to the positive terminal of the battery. This is caused by current taking the path of least resistance. Since current is flowing through coil 2, a magnetic field is set up in coil 2, and the south pole of the coil attracts the north pole of the permanent magnet attached to the pointer. This attraction of the poles rotates the pointer to the "E" position as shown.

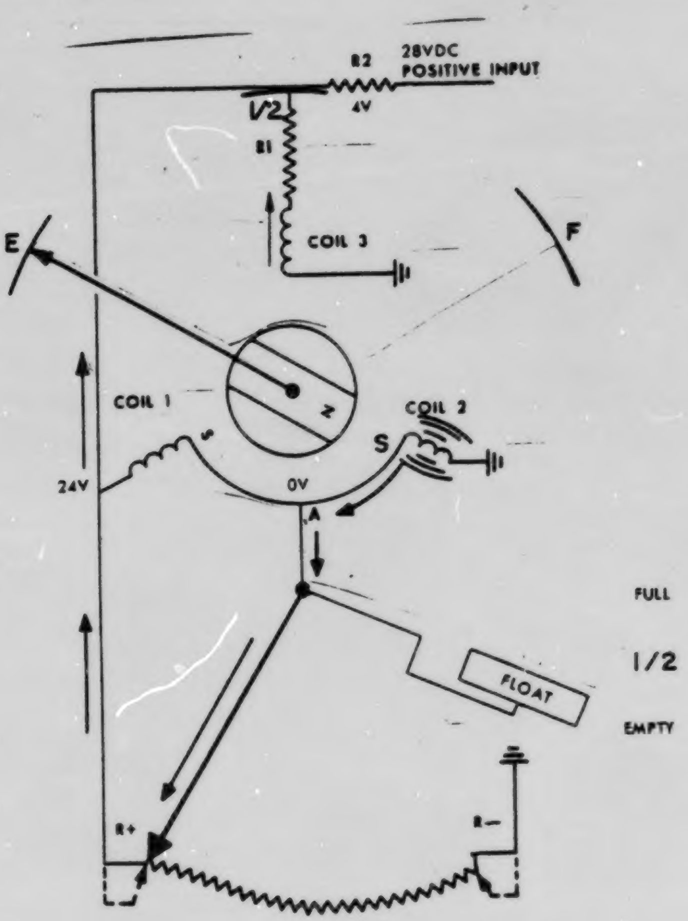
R2
28VDC
POSITIVE INPUT
4V
1/2
R1
COIL 3
E
F
COIL 1
N
COIL 2
S
S
24V
0V
A
FULL
1/2
EMPTY
FLOAT
R+
R−

Figure 13

Circle the letter of the correct response to the following statement(s). Use figure 13.

1. The coil that does not have current flow through it is coil

   a. 1.
   b. 2.
   c. 3.

Frame 16

The second level of liquid to be discussed is shown in figure 14. Notice the position of the float and the wiper arm. Current flow at this time will be from ground through the resistance strip to the battery and also from ground through coil 1 and coil 2. Since the wiper arm is halfway between the ends, the voltage drop on each side of the wiper arm is 12 volts. The same is true with coil 1 and coil 2, each having 12 volts. Since coil 1 and coil 2 are equal, their magnetic attraction of the north pole of the rotor is equal and the pointer will be centered.

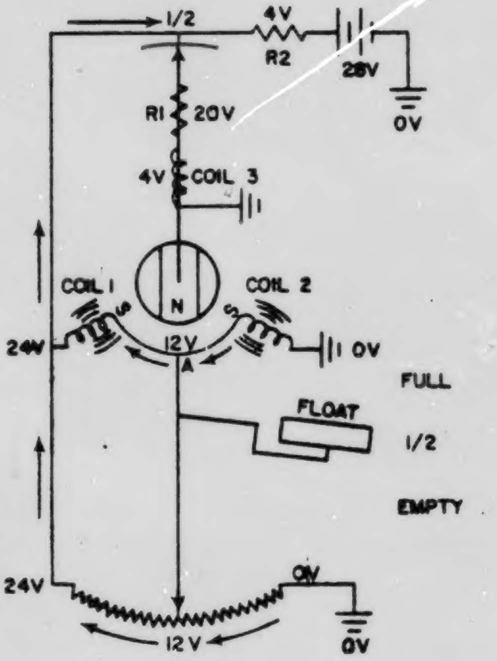

Figure 14

Circle the letter of the correct response to the following statement(s).

1. When the wiper arm is centered the current is

   a. greater in coil 1 than coil 2.
   b. greater in coil 2 than coil 1.
   c. equal in coil 1 and coil 2.

Answer to Frame 15: 1. a

Frame 17

The last level of liquid to be discussed is shown in figure 15. Notice the position of the float and wiper arm. Current flow is from ground through the wiper arm and coil 1 to the battery. Coil 2 has no current through it due to current taking the path of least resistance. With current flowing through coil 1 magnetic poles are set up and the south pole of coil 1 attracts the north pole of the rotor and rotates the pointer to the position shown.

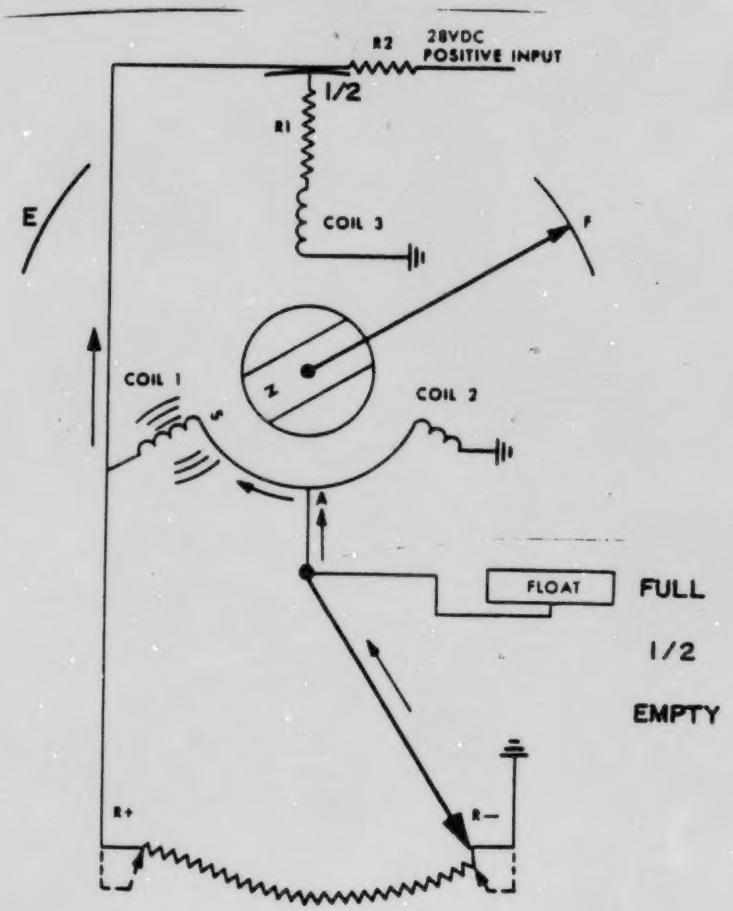
R2
28VDC
POSITIVE INPUT
1/2
R1
COIL 3
E
F
COIL 1
S
N
COIL 2
A
FLOAT
FULL
1/2
EMPTY
R+
R—

Figure 15

NO RESPONSE REQUIRED

Answer to Frame 16: 1. c

Frame 18

The R plus and the R minus adjustments, shown in figure 16, are used for making minor adjustments on the indicator reading. These adjustment screws are used for calibrating the amount of resistance in the resistance strip. The R minus adjustment is used for the full side of the transmitter and the R plus adjustment is used for the empty side of the transmitter. If the indicator is reading slightly high or low at the full position, the R minus adjustment screw can be turned to correct the indication. If the indicator cannot be brought into adjustment, there is another adjustment to be made. This is called the centering adjustment "C." This is done by adjusting the wiper arm along the resistance strip so that the indicator pointer will be the same distance from both ends of the scale when the tank is 1/2 full.

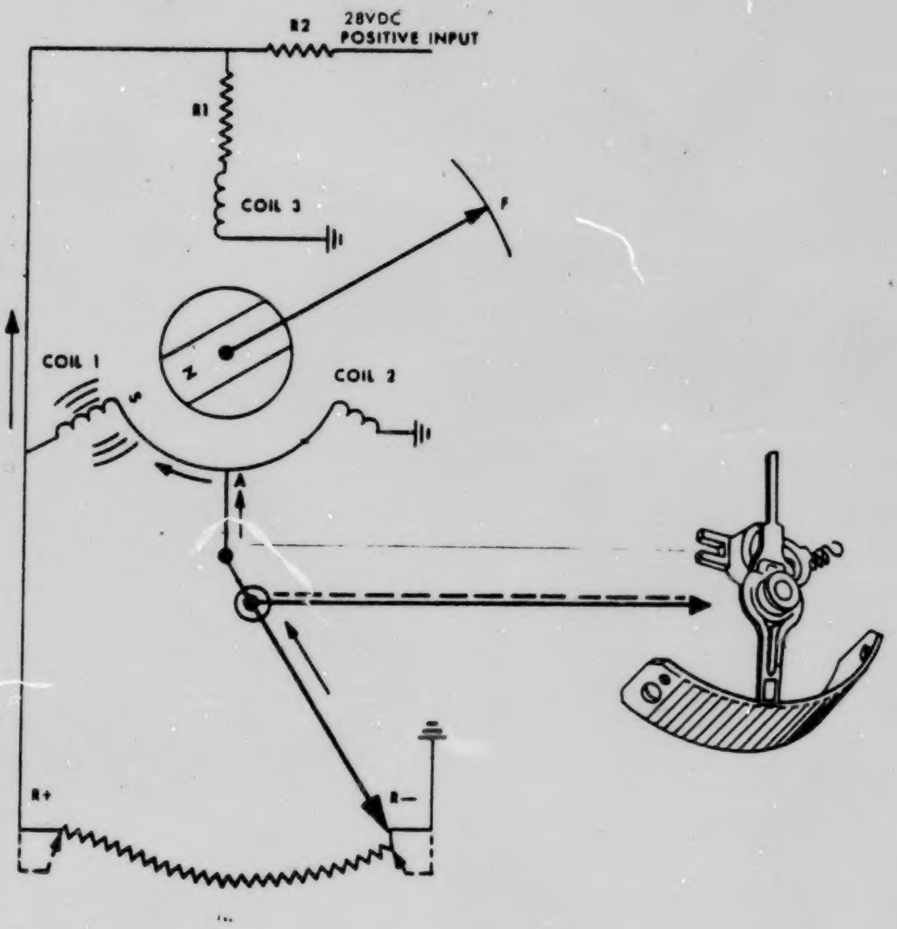

Figure 16

Circle the letter of the correct response to the following statement(s).

1. The R plus and R minus screws are used for calibrating transmitter

   a. resistance.
   b. position error.
   c. friction error.
   d. voltage output.

2. The centering adjustment is performed by adjusting the

   a. R screw.
   b. R- screw.
   c. float arm.
   d. wiper arm.

Now that you have completed frame 18, go back to the beginning of this PT and reread all of the objectives again. When you feel you understand the material, ask the instructor for the appraisal on the Resistance-Type Liquid Quantity Indicating System.

After you have satisfactorily completed the appraisal, you will proceed to the laboratory to apply your knowledge to an actual system.

Answers to Frame 18: 1. a, 2. d.

881

WORKBOOK
3ABR32531-WB-207

Technical Training

Avionics Instrument Systems Specialist

RESISTANCE-TYPE LIQUID QUANTITY SYSTEM

2 September 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

9'2

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-207

INSPECTION, OPERATIONAL CHECK, TROUBLESHOOTING AND BENCH CHECK THE RESISTANCE-TYPE LIQUID QUANTITY SYSTEM AND COMPONENTS

OBJECTIVES

Given a workbook and trainer, perform an inspection and operational check of the resistance-type liquid quantity system with a minimum of 100% correct workbook responses.

Given a workbook, test equipment and trainer, troubleshoot the resistance-type liquid level indicating system with a minimum of 100% correct workbook responses.

Given a workbook, test equipment and trainer, bench check components of the resistance-type liquid level indicating system with a minimum of 100% correct workbook responses.

EQUIPMENT

	Basis of Issue
3ABR32531-WB-207	1/student
Trainer 18-71-4144	1/student
Wheatstone Bridge	1/student
Wheatstone Bridge Leads	2/student
Multimeter	1/student
TO 33A1-12-15-1 EXTRACT	1/student

PROCEDURE

Remove ALL JEWELRY before working with electrical equipment. DO NOT damage trainer or test equipment. Place a checkmark (✓) or response in appropriate blank or blanks.

Note: Obtain ALL necessary equipment before starting lab.

Part 1. INSPECTION

1. Visually inspect the indicator for:	SAT	UNSAT
a. Cracked or loose glass.	______	______
b. Condition of dial.	______	______
c. Condition of pointers.	______	______
d. Damaged case.	______	______
e. Security of mounting.	______	______

Supersedes 3ABR32531-WB-212, 22 January 1975, which may be used until existing stocks are exhausted.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 200; TTVSR - 1

	SAT	UNSAT
f. Condition of electrical connector.	______	______
2. Inspect the tank unit for:		
a. Damaged case.	______	______
b. Security of mounting.	______	______
c. Damaged mounting flange.	______	______
d. Condition of electrical connector.	______	______
e. Condition of float and arm assembly.	______	______
3. Inspect the wiring for:		
a. Frayed insulation.	______	______
b. Broken connector plugs.	______	______
c. Broken wires.	______	______

Part 2. OPERATIONAL CHECK

1. Plug trainer into 28V DC power source.

2. Push circuit breaker IN.

3. Place trainer switch to ON position.

Note: Make sure all trouble switches are to the OUT position.

4. With float arm in (down) EMPTY position, the indicator reads empty _____, full _____.

5. Move float arm to (up) FULL position. Indicator reads empty _____, full _____.

6. Move float arm to (down) EMPTY position. Indicator reads empty _____, full _____.

Part 3. TROUBLESHOOTING

1. Place trouble switch #1 to the IN position

a. Indicator reads OFF scale empty _____, OFF scale full _____, low _____, high _____.

b. Move float arm through its full range of travel. Indicator moves _____, does not move _____.

2. Place trouble switch #1 to the OUT position and place trouble switch #2 to the IN position.

a. Indicator reads OFF scale empty _____, OFF scale full _____, low _____, high _____.

b. Move float arm through its full range of travel. Indicator moves _____, does not move _____.

3. Place trouble switch #2 to the OUT position and place trouble switch #3 to the IN position.

a. Indicator reads OFF scale empty _____, OFF scale full _____, low _____, high _____.

b. Move float arm through its full range of travel. Indicator moves _____, does not move _____.

4. Place trouble switch #3 to the OUT position and place trouble switch #4 to the IN position.

a. Indicator reads OFF scale empty _____, OFF scale full _____, low _____, high _____.

b. Move float arm through its full range of travel. Indicator moves _____, does not move _____.

5. Place trouble switch #4 to the OUT position.

6. Place trainer power switch to OFF position.

7. Pull circuit breaker.

8. Disconnect trainer from 28V DC power source.

9. Remove electrical connector plugs from indicator and transmitter.

10. Using the multimeter, troubleshoot the system and record the kind of trouble and location of trouble on the following chart.

a. Place function switch to OHMS.

b. Place range switch to Ω X 1.

Trouble Switch	Indication (Kind of Trouble) Open, Short, etc.	Location of Trouble (Wire Number(s))
1		
2		
3		
4		

11. Make sure all trouble switches are to the OUT position.

12. Reconnect the electrical connector plugs to the indicator and transmitter.

Note: Make sure keyways are aligned.

Part 4. BENCH CHECK

1. Plug trainer into 28V DC outlet.

2. Push circuit breaker IN.

3. Place trainer switch to ON position.

Note: Make sure all trouble switches are to the OUT position.

4. Move float arm through its full range of travel to full position.

   a. Indicator reads empty _____, full _____.

5. Move float arm through its full range of travel to empty position.

   a. Indicator reads empty _____, full _____.

6. Indicator is satisfactory _____, unsatisfactory _____.

7. Turn trainer switch to OFF.

8. Pull circuit breaker.

9. Disconnect trainer from 28V DC power source.

10. Disconnect electrical connector plug at transmitter.

11. Using a Wheatstone bridge, check the resistance of the resistance strip in the DC liquid level transmitter.

12. Connect the Wheatstone bridge leads to pins A and B of the transmitter, and X1 and X2 post on the Wheatstone bridge.

13. Position GA knob to the RVM position.

14. Position BA knob to the INT position.

15. Position the RES-VAR-MUR knob to the RES position.

16. The resistance of the resistance strip of the transmitter should be 201 ohms plus or minus 4 ohms.

17. Position the "MULTIPLY BY" switch to 1/10 position LAW chart located in TO EXTRACT 33A1-12-15-1.

18. Push the galvanometer pointer lock (clamp) button toward DIAL to unlock galvanometer pointer.

19. Turn the ZERO ADJUST knob located ABOVE the lock button until the galvanometer pointer is at ZERO.

20. Position the thousands, hundreds, tens and units decade dials to the settings that total the estimated resistance from step 16.

21. Follow the instructions in paragraph 14 sub-para "b" (1) and (2) of TO EXTRACT 33A1-12-15-1, to measure the resistance of the resistance strip of the DC transmitter.

22. The resistance is _____ ohms.

a. Satisfactory _____, Unsatisfactory _____.

23. Lock the galvanometer pointer.

24. Using the multimeter, check the wiper arm of DC transmitter. Multimeter should be on Ohms X 1 scale.

a. Connect wheatstone bridge leads to pin A and pin C of the DC transmitter.

b. Clip ohmmeter leads to alligator clips on wheatstone bridge leads.

25. Move the transmitter float UP and DOWN. The resistance should vary smoothly.

a. Wiper arm is satisfactory _____, unsatisfactory _____.

26. Connect the electrical connector plug to transmitter.

27. Disconnect leads from multimeter and wheatstone bridge and store wheatstone bridge and multimeter.

28. Student's Last Name ____________________________.

29. Give wheatstone bridge leads and workbook to instructor.

887

1 volt through 1 megohm. When using the 4½-volt internal battery, one megohm of resistance will cause the pointer to deflect 4½ scale divisions.

b. Shorts and Crosses. Wires in cable are commonly arranged in pairs (A, fig. 5). An electrical path between two wires of the same pair is commonly called a short. An electrical path between two wires of adjacent pairs is commonly called a cross (C, fig. 5). Test for a short or a cross as follows:

(1) Prepare the test set (a(1)-(4) above).

(2) Disconnect all equipment from the far end of the cable.

(3) Connect one of the wires to be tested to the ground binding post and press the GA SENS 1 switch. Touch each of the other wires in the cable to line binding post X1. The galvanometer will deflect strongly when the other faulty wire contacts line binding post and will show no deflection with wires not shorted or crossed.

c. Open Conductor.

(1) Perform a(1) through (5) above.

(2) If the wires to be tested are in lead-covered cable, connect the far end of the wires in the cable to the cable sheath. If the cable is not lead-covered, connect the far end of the wires to a good ground.

(3) Press GA SENS 1 switch and touch each of the wires at the near end (one at a time) to line binding post X1. The galvanometer will deflect for all wires except any that are open.

14. Measurement of Loop or Unknown Resistance

Measure the resistance of a loop (two lengths of wire joined at the distant end) or of any electrical component (resistors, transformers, etc.) as follows:

a. Preparation for Test.

(1) Adjust the galvanometer (par. 10a).

(2) Position the test set controls (fig. 3) as follows:

(a) GA switch to RVM.

(b) RES-VAR-MUR switch to RES.

(c) Make as close an estimate as possible of the resistance to be measured and set the MULTIPLY BY dial as indicated in the following chart:

Estimated resistance (ohms)	MULTIPLY BY dial setting
Below 10	$\frac{1}{1000}$
10 to 100	$\frac{1}{100}$
100 to 1000	$\frac{1}{10}$
1000 to 10,000	$\frac{1}{1}$
10,000 to 100,000	$\frac{10}{1}$ [a]
100,000 to 1,011,000	$\frac{100}{1}$ [a]

---

[a] To obtain more sensitive measurements (greater pointer deflections) when measuring resistances above 10,000 ohms, use an external 22½- or 45-volt battery (Battery BA-48) or equal.

(3) Make the following connections:

(a) If the resistance of a loop is to be measured, disconnect all equipment from the near end of the loop and connect one wire of the loop to line binding post X1 and the other wire to line binding post X2 (A, fig. 5). Be sure that the wires connected to the test set are clean and are firmly secured to the binding posts. Have all equipment disconnected from the far end of the loop and a short placed across the circuit at that end.

(b) If the resistance of an electrical component is to be measured, connect the component across line binding posts X1 and X2.

b. Balancing the Bridge.

(1) Position the thousands, hundreds, tens, and units decade dials (fig. 3) to settings that total the estimated

resistance to be measured divided by the setting of the MULTIPLY BY dial.

Example: If the estimated resistance to be measured is 500 ohms, the setting of the MULTIPLY BY dial must be 1/10 (chart in *a* above); therefore the positions of the decade dials must total 5,000.

$$\frac{\text{Estimated resistance to be measured}}{\text{Setting of MULTIPLY BY dial}} = \frac{500}{\frac{1}{10}} = 5{,}000$$

(2) Press the GA SENS .01 switch and note the direction of movement of the galvanometer pointer. If it moves to the right, increase the resistance total of the decade dials until it does not move from zero when the GA SENS .01 switch is pressed. If the pointer moves to the left, decrease the resistance total of the decade dials. Repeat the above procedure, using the GA SENS .1 and then the GA SENS 1 Switches. The test procedure is complete when the GA SENS 1 switch is pressed and the pointer does not move in either direction. Under these conditions, the bridge circuit in the test set is said to be balanced.

c. Resistance Determination. The unknown resistance is equal to the sum of the decade dial settings multiplied by the setting of the MULTIPLY BY dial.

Example: If the bridge is balanced when the sum of the decade dial settings is 5,137 and the MULTIPLY BY dial is set at 1/10, the resistance connected across the line binding posts is 5,137 x 1/10 or 513.7 ohms (decimal point moved one place to left). If the MULTIPLY BY dial is set at 1/100, move the decimal point two places to the left (51.37 ohms); for 1/1000, move the decimal point three places to the left (5.137 ohms). For 10/1, add one zero to the reading (51,370 ohms) and for 100/1, add two zeros (513,700 ohms).

15. Simple Loop Test for Locating Short

A simple method of locating a short is to determine the resistance of the short, subtract the resistance of the short from resistance measurements from each end of the shorted circuit, and use the resulting resistance value and the known resistance per mile or feet per ohm of the type of wire in the faulty circuit to compute the resistance from each end to the fault. When a fault has been identified as a short, have all equipment disconnected from both ends of the circuit and proceed as follows:

a. Determination of Loop Length (Test 1, fig. 5). If the length (distance from test point to far end) of the faulty loop is not known, compute it as follows:

(1) Measure the loop resistance of a good pair in the cable (par. 14).

(2) Determine the loop length in miles by dividing the resistance per loop mile (par. 33) into the loop resistance. To compute the loop length in feet, multiply one-half the loop resistance by the number of feet per ohm of the wire.

b. Measurement from Test Point to Short (Test 2, fig. 5). Connect the shorted pair to line binding posts X1 and X2 and balance the bridge. Record the resistance measurement.

Note. This resistance is equal to the resistance of the short plus the resistance of the shorted circuit from the test point to the fault.

c. Equivalent Measurement from Far End (Test 3, fig. 5). Have a good cable pair connected to the shorted pair at the far end. Disconnect the shorted pair from the test set, connect the good pair to line binding posts X1 and X2, and measure the resistance of this circuit arrangement. Subtract the loop resistance (*a*(1) above) from the test 3 resistance measurement to obtain an equivalent resistance measurement from the far end of the shorted circuit.

Note. This resistance is equal to the resistance of the short plus the resistance of the shorted circuit from the far end to the fault.

d. Resistance of Short. Subtract the loop resistance (*a*(1) above) from the sum of the resistance measurement from each end of the

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PROGRAMMED TEXT 3ABR32531-PT-208

3ABR32632B-PT-307

Technical Training

AVIONIC'S INSTRUMENT SYSTEMS SPECIALIST
INTEGRATED AVIONIC SYSTEMS SPECIALIST

F-111 CAPACITANCE INDICATING SYSTEM

16 January 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
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FOREWORD

This programmed text was prepared for use in Courses 3ABR32531, Avionic Instrument Systems Specialist and 3ABR32632B, Integrated Avionic Systems Specialist. The material contained herein has been validated with 20 students from the 3ABR32531 Course and 30 students from the 3ABR32632B Course. At least 90% of the students achieved the objective as stated. Average time for completion of the test was 1 hour and 23 minutes.

OBJECTIVE

Without references, identify facts pertaining to the purpose, operation, and/or characteristics of the capacitance liquid quantity indicating system with an accuracy of 80%.

INSTRUCTIONS

This program presents information in small steps called "FRAMES." After reading the information in each frame, you are asked to actively respond on the response sheet provided. Check the accuracy of your response with the correct answers that are given after the following frame. If you make an incorrect response, study the frame again before going on to the next frame. DO NOT HURRY!

DO NOT WRITE IN THIS BOOK!

Supersedes 3ABR32531-PT-213, 3ABR32632B-PT-305, 7 November 1974.
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The F-111 aircraft has two capacitance liquid quantity indicating systems, fuel and oxygen. They are used to indicate how much fuel and oxygen are in the tanks so that the pilot can plan for successful completion of his mission. Basically, both systems are the same so we will study the fuel quantity indicating system. Particulars of the oxygen quantity system will be given in the last few frames of this programmed text. The fuel quantity indicating system that was used on earlier aircraft measured the fuel in gallons. This type of system had one major problem. As the temperature changed, the amount of fuel displayed on the indicator changed. This was caused by the expansion and contraction of the fuel at different temperatures. When the temperature increases the volume of the fuel increases and thus the indication increases. The opposite occurs when the temperature decreases. Therefore, this type of system was very inaccurate and would not meet the needs of modern aircraft.

Circle the letter of the correct response to the following statement.

1. As the temperature of the fuel decreases, the volume of the fuel

   a. increases.
   b. decreases.
   c. stays the same.

892

Frame 2

With the development of high performance aircraft, such as the F-111, fuel measurement became extremely important. Through experimentation it was discovered that even though the volume of fuel changes with temperature changes, the weight of fuel remains approximately the same for each different type of fuel. The system developed to accurately measure the fuel is a capacitance AC bridge circuit system. This system measures the weight of fuel aboard an aircraft and thus eliminates the errors caused by temperature changes.

Circle the letter of the correct responses to the following statements.

1. The capacitance type fuel indicating system was developed to improve

   a. stability of the aircraft.
   b. maintenance of the aircraft.
   c. maneuverability of the aircraft.
   d. accuracy in measurement of fuel in the tanks of the aircraft.

2. The system developed to measure the amount of fuel is a/an

   a. inducatance AC bridge circuit.
   b. capacitance AC bridge circuit.
   c. resistance AC bridge circuit.

Answer to Frame 1: 1. b

Before we cover the components of the capacitance fuel quantity system, let's review some basic facts about capacitors. A capacitor (or condensor, as it is often referred to) is an electrival device in which an electrical charge can be stored. It is composed of two conductors separated by an insulator (dielectric). The capacitance of a capacitor is measured in farads (f). However, the farad is such a large unit that most capacitors used in the capacitance quantity system are rated in micromicro farads (μμf). The capacitance of a capacitor depends upon three factors: (1) the surface area of the plates, (2) the distance between the plates, (3) the material or dielectric between the plates.

Circle the letter of the correct responses to the following statements.

1. Which of the following terms is used to measure a capacitor's capacitance?

   a. Henry
   b. Ohm
   c. Farad
   d. Hole

2. The capacitance of a capacitor depends on the surface area of the plates.

   a. dielectric, and distance between the plates.
   b. dielectric, and material the plates are made of.
   c. material of the plates, and distance between the plates.

Answers to Frame 2: 1. d 2. b

Frame 4

Figure 1 below is a basic capacitive circuit. When the switch is closed, electrons leave the negative side of the battery and are applied to the left plate of the capacitor. This develops a negative charge on the left plate due to the excess electrons. At the same time that the electrons leave the battery, electrons are pulled from the right plate of the capacitor by the positive terminal of the battery. This causes the right plate to assume a positive charge due to the lack of electrons on this plate. Current will flow in the circuit in the direction of the arrows until the capacitor has charged to its full capacity. The capacitor will remain at this capacity as shown in figure 2, with the switch opened, until a path for discharge is provided. In figure 3, a path for discharge has been supplied through the closed switch 2. This allows the electrons to leave the left plate and travel through the circuit to the right plate. This continues until the left and right plates are equal and then the capacitor is considered discharged.

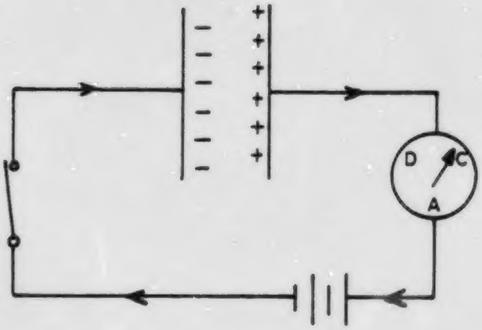


Figure 1.

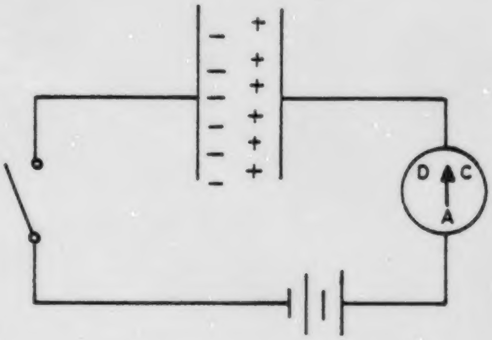


Figure 2.

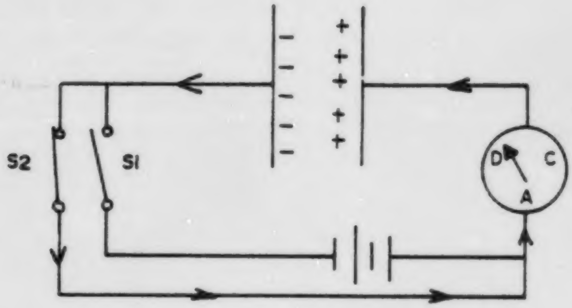


Figure 3.

NO RESPONSE REQUIRED

Answers to Frame 3: 1. c 2. a

To change the amount of electrons that can be stored by a capacitor the dielectric must be changed. Various materials are given a dielectric number (K factor) which compares to the dielectric constant of a vacuum which has a K factor of 1. Table 1 below lists the dielectric constants of several materials. (The water listed in Table 1 is distilled water, otherwise it would not be a good dielectric.) The higher the K factor, the greater the capacitance of a capacitor.

VACUUM	1.00000
AIR	1.00059
115/145 GRADE AVIATION GASOLINE	1.971
JP-4 FUEL	2.083
MICA	5.7 to 7.0
WATER	81.7

Table 1. Dielectric Constants

Circle the letter of the correct responses to the following statements.

1. Of the dielectrics listed below, the one having the highest K factor is

   a. air.
   b. mica.
   c. vacuum.
   d. JP-4 fuel.

896

Frame 6

In figure 4 below, a capacitor is shown with air as the dielectric. This causes a certain amount of capacitance. Notice that using air as a dielectric the battery causes a certain number of electrons to build up on the negative plate and a certain number of electrons are removed from the postive plate. In figure 5 below, the dielectric used is fuel. This results in more capacitance than in figure 4, although the two capacitors are identical. This dielectric allows more electrons to be stored on the negative plate and more electrons to leave the positive plate. Because fuel has a higher "K" factor than air, the capacitance of the capacitor is greater. This changing of capacitance because of the dielectric changing is the basic principle of operation of the Capacitance Fuel Quantity Bridge Circuit.

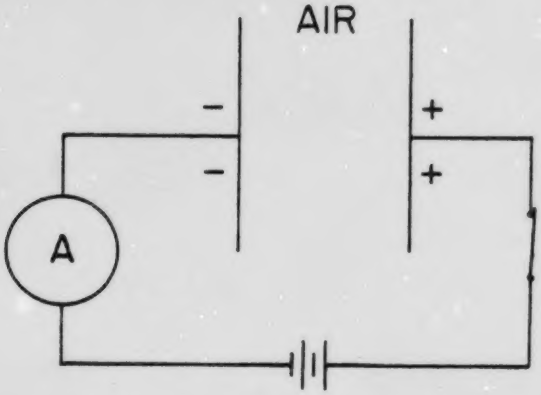


Figure 4.

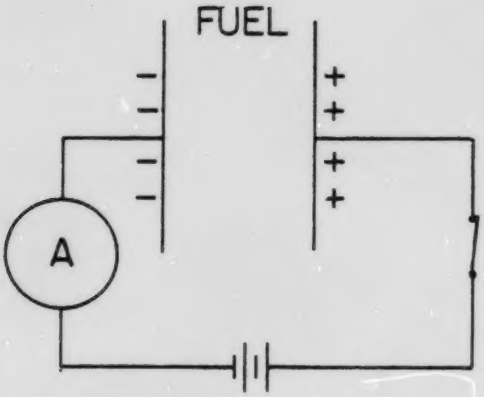


Figure 5.

Circle the letter of the correct responses to the following statements.

1. When the dielectric constant of a capacitor is increased, the capacitance

   a. increases.
   b. decreases.
   c. stays the same.

Answer to Frame 5: 1. b

898

Frame 7

A simple capacitance bridge circuit consists of a tank unit and a reference capacitor connected in series across a secondary winding of a transformer. The tank unit is shown as a variable capacitor and the reference capacitor is shown as a fixed capacitor. See figure 6 below. A center tap from point "K" on the secondary winding is connected through an amplifier to point "P" between the reference capacitor and the tank unit. If the tank unit and the reference capacitor are equal and the center tap divides the voltage of the secondary, then the induced voltage on each leg is equal. The current developed in each leg tries to flow across the bridge but from different directions. Since the current is equal they "buck" (oppose) each other and all the current flows in the direction shown by arrows in figure 6 and no current is felt across the bridge. At this time the bridge is said to be balanced.

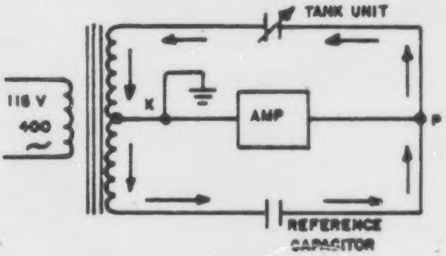


Figure 6.

Circle the letter of the correct responses to the following statements.

1. The bridge circuit shown above is balanced because the two currents are

   a. equal in value and opposite in direction.
   b. equal in value and in the same direction.
   c. unequal in value and opposite in direction.

2. The reference capacitor in the circuit is the

   a. variable capacitor and is in series with the tank unit.
   b. fixed capacitor and is in series with the tank unit.
   c. fixed capacitor and is in parallel with the tank unit.
   d. variable capacitor and is in parallel with the tank unit.

Answer to Frame 6: 1. a

919.

Figure 8

When fuel is added to the tanks, the capacitance bridge becomes unbalanced; the capacitance of the tank unit increases and the capacitive reactance decreases, allowing a greater current to flow in the tank unit leg. This increased current in the tank unit leg overcomes the current in the reference capacitor leg of the bridge circuit. The current is then able to travel in the direction of the arrows across the bridge. See figure 7 below.

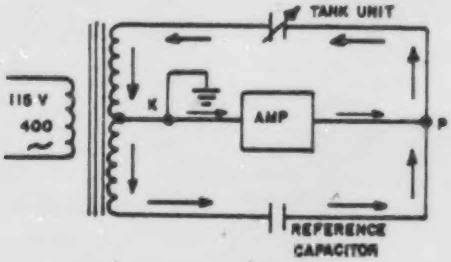


Figure 7.

Circle the letter of the correct responses to the following statements.

1. By adding fuel to the tank the capacitive reactance of the tank will

   a. increases.
   b. decreases.
   c. stays the same.

2. As the tank unit capacitance increases,

   a. more current will flow in that circuit.
   b. less current will flow in that circuit.
   c. current flow will stay the same in that circuit.

Answers to Frame 7: 1. a 2. b

Frame 9

Since current flows across the bridge to the amplifier, an amplified signal is being applied to the indicator and a pointer is being repositioned. A way is needed to stop the pointer movement at the correct position, so a rebalance potentiometer is added to the circuit in series with the reference capacitor. See figure 8 below. The wiper arm of the potentiometer is repositioned whenever the pointer is moved which will readjust the voltage to the reference capacitor and stop the pointer movement at the correct position. This is done by cancelling the current across the bridge. At this time the bridge has been rebalanced.

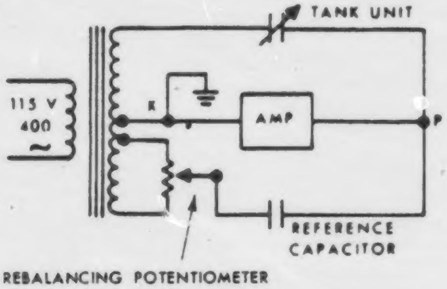


Figure 8.

Circle the letter of the correct responses to the following statements.

1. The rebalance potentiometer is connected to the reference capacitor in

   a. series.
   b. parallel.
   c. series-parallel.

2. As the rebalance potentiometer wiper arm moves, voltage will

   a. be varied across the reference capacitor.
   b. be varied across the tank unit.
   c. stay the same across the reference capacitor.
   d. stay the same across the tank unit.

Answers to Frame 8: 1. b 2. a

Figure 10

Now that the current flow has been stopped through the bridge, the system is balanced. As the amount of fuel decreases, (used by the engine) the bridge circuit becomes unbalanced again. The decrease in fuel causes the capacitance of the tank unit to decrease and the reactance to increase. Because of the increase of the reactance, the current in the tank unit leg decreases. At this time the current in the reference leg is greater and flows across the bridge through the amplifier from point "P" to point "K." Notice the direction of the current flow (arrows) in figure 9 below. The amplified signal operates the indicator and the rebalance potentiometer is readjusted to balance the bridge.

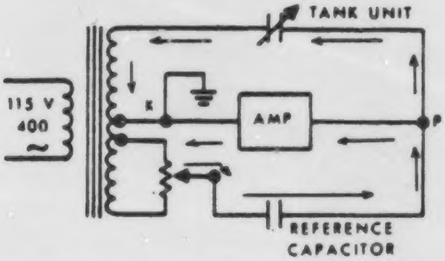


Figure 9.

Circle the letter of the correct responses to the following statements.

1. When fuel is taken from the tank, the capacitive reactance of the tank unit

   a. increases.
   b. decreases.
   c. stays the same.

2. As the tank unit capacitance decreases,

   a. less current flows through the tank unit.
   b. more current flows through the tank unit.
   c. less current flows through the reference capacitor.

Answers to Frame 9: 1. a 2. a

902

Frame 11

When the capacitance fuel quantity system is in operation, another factor that affects the indication is the fuel characteristics (dielectrics). Some fuel lots, or batches, will have a higher dielectric constant than the others. This is especially true of modern jet fuels. In order to minimize the effects of these differences in dielectric, a special capacitor (compensator) is used. The compensator (Item A of Figure 10) is always located at the lowest point of the tank. Electrically, the compensator is actually a variable capacitor only smaller in size than the regular tank unit (Item B).

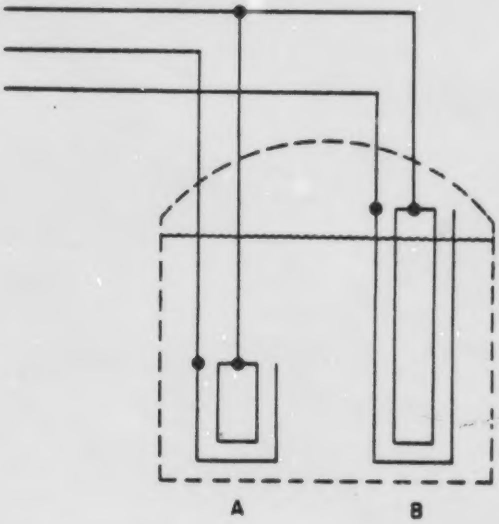


Figure 10.

NO RESPONSE REQUIRED

Answers to Frame 10: 1. a 2. a

The compensator is electrically connected in parallel to the reference capacitor of the bridge circuit. (See figure 11 below.) The compensator works as follows. When fuel, from a different lot, is added to the tank the K factor may be higher than the K factor of the previous lot of fuel. This causes a higher current to flow in the variable leg of the bridge circuit. The higher current flow increases the reading of the indicator even though the fuel tank holds the same amount of fuel. With the compensator installed at the bottom of the tank the K factor felt on the tank unit is also felt on the compensator. So therefore, if the K factor causes an increase in current flow in the tank unit, the current flow will also increase in the compensator. Since the compensator is connected in parallel with the reference capacitor, the increased current flow of the compensator will be added to the current flow of the reference capacitor. This causes both legs of the bridge to increase the same amount and therefore the K factor difference is corrected for by the two increased signals cancelling each other.

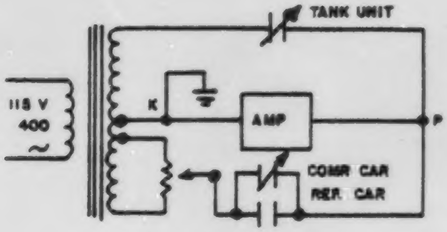


Figure 11.

Circle the letter of the correct responses to the following statements.

1. The compensator is connected to the reference capacitor in

   a. series.
   b. parallel.
   c. series-parallel.

2. The compensator unit is connected to the reference capacitor and

   a. aids the tank unit current.
   b. opposes the tank unit current.
   c. raises the tank unit current.

Frame 13

Now that the operation of a basic Capacitance Bridge Circuit has been explained, let's cover each component used to make-up the four sections (Forward, Aft, Select, and Total) of the F-111 Capacitance Fuel Quantity Indicating System. The first component to be discussed is the tank unit probe (variable capacitor). See figure 12 below. The tank unit probe is a light weight sensing element that consists of two concentric tubes, one inside the other and are separated by an insulated spacer to prevent them from shorting together. These tubes make up the inner and outer plates of the variable capacitor which has the capacitance rated in micromicrofarads (pico). Openings at each end of the tubes are provided to allow the fuel to enter the tubes so that the fuel is used as the dielectric.

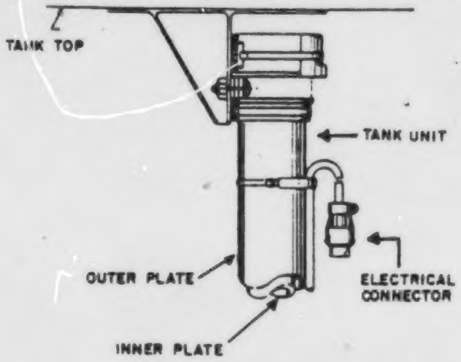


Figure 12.

Circle the letter of the correct response to the following statements.

1. The capacitance of the tank unit probes are rated in

   a. ohms.
   b. farads.
   c. millifarads.
   d. picofarads.

Answers to Frame 12: 1. b 2. b

With the exception of the tank units (probes) in the wings, all probes are dual-sensor devices. That is there are two identical but electrically isolated sensing elements mounted on a common flange or installation bracket. Tank units for the wings are single-sensor units but are installed in pairs, achieving the same purpose as the dual-sensor units. One sensing element of the pair is connected in electrical parallel with one element of each pair within that particular tank to provide sensing of the individual tank fuel quantity. The other element of the pair is connected in electrical parallel with the other elements of that tank and also to the other tanks to provide the total fuel quantity indication, which makes the totalization completely independent of the individual tank indivations. Both sensing units are identical; therefore, it is immaterial which one is connected in either the individual tank or totalizer circuits.

Circle the letter of the correct response to the following statement.

1. Single-sensor units are connected in pairs and are used

   a. to take the average capacitance.
   b. to decrease the capacitance of the individual tank.
   c. to increase the capacitance of the individual tank.
   d. one for the individual tank, and one for the totalizer.

Answer to Frame 13: 1. d

Frame 15

More than one set (pair) of probes is used in a fuel tank system and are connected together in parallel, (remember that the total capacitance of capacitors in parallel is the sum of the individual capacitances), so that aircraft manuevers (changes in attitude) are possible without causing the capacitance quantity indication to change. See figure 13 below. Notice the dotted line across the fuel tank. If the aircraft were in a climb as shown below, the indication would still be as if the aircraft were flying level and the level of fuel were at the line shown. Thus, the total capacitance of the tank is used for the indication.

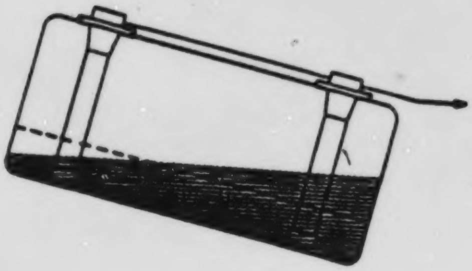


Figure 13.

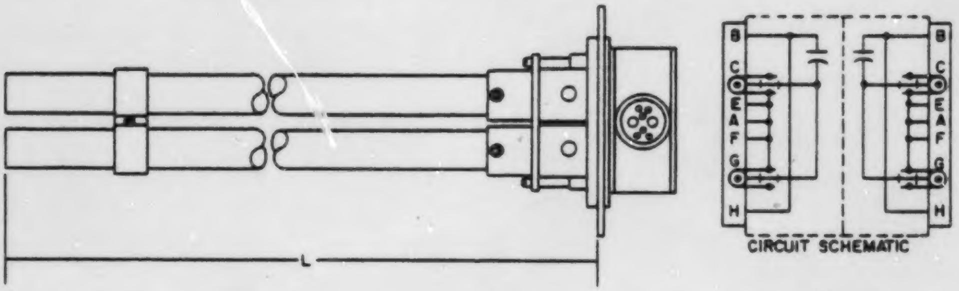
Circle the letter of the correct responses to the following statements.

1. The probes (pairs) are connected in parallel to prevent an indication change of the indicator due to

   a. dielectric change.
   b. aircraft manuevers.
   c. a shorted probe in the tank.
   d. a weak battery in the system.

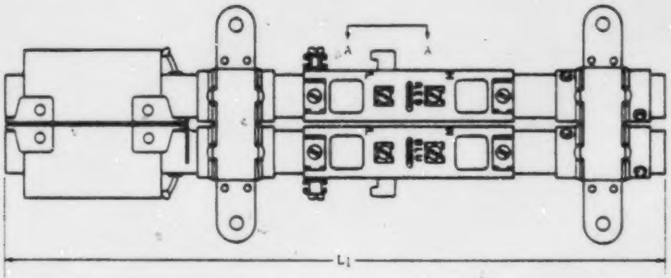
Answer to Frame 14: 1. d

The number and size of the probes (pairs) depend on the size and shape of the tank in which they are to be used. There are two types of mounting probes that are widely used. They are the flange mounted (mounted vertically from the outside of the tank) as shown in figure 14 and the internally mounted type (mounted vertically inside the tank) as shown in figure 15. Notice that in each type two probes are used, one for the individual system and the other for the total system.



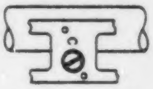
INSERTION LG L (±.03)	DRY CAP UUF	VENDOR PART NO.
18.52	37.51	B1256-3177
50.53	73.73	-3178
47.89	109.52	-3179
52.69	161.59	B1256-3475
42.63	85.89	-3476

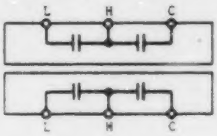
Figure 14.



OVERALL LENGTH L1 (±0.03)	DRY CAP UUF	VENDOR PART NO.
13.14	14.89	81298-3483

COMPENSATOR DRY CAP=26.8 UUF


VIEW A-A (TYP)



CIRCUIT SCHEMATIC

Figure 15.

NO RESPONSE REQUIRED

Answer to Frame 15: 1. b

Frame 17

The inner tubes (plates) of the tank units are one of two types: (1) the non-characterized type which is used in tanks that are uniform in design such as a square or rectangular shaped tank, and (2) the characterized type which is used in tanks that are irregular in design. The non-characterized type inner plate is made so that the complete plate capacitance is used in the system. See figure 16*. The characterized type inner plate, as shown in figure 17*, is not uniform in width (shaded area) along the plate length because of the irregular tank that it is to be used in. This type of inner plate consists of two metal patterns (shaded and white) which are insulated from each other and pressed together to form the inner plate. The tube is coated with a phenollic resin varnish to prevent shorting. The active area (shaded) is attached to a signal lead and the white area is connected to ground to remove the unwanted capacitance from the system. With this set-up, the correct capacitance is achieved so that an evenly graduated indicator can be used regardless of the shape of the tank.

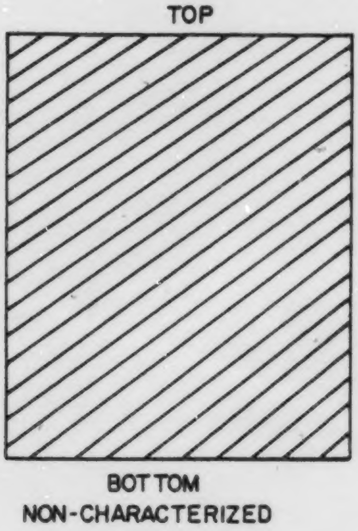


Figure 16.

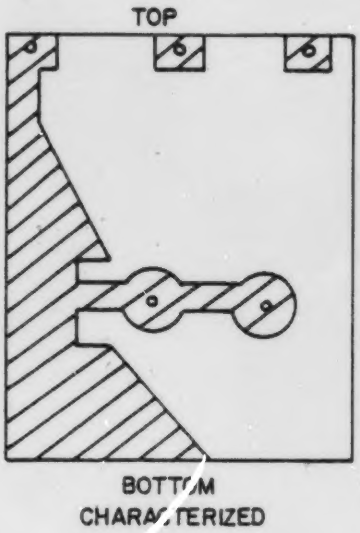


Figure 17.

*Note: The above figures are an unrolled view of the inner plates.

Circle the letter of the correct response to the following statements.

1. The type of inner plate that is used in an irregular shaped tank is the

   a. Characterized type.
   b. Non-Characterized type.

The signal lead that is attached to the active pattern of the inner plate is a shielded (coaxial) lead which is referred to as a COAX lead. The COAX lead is made up of 4 parts. See figure 18 below. The parts are: a low resistance center conductor to carry the signal, a dielectric insulation to prevent shorting, a shield (outer conductor) which is grounded to protect the center conductor from unwanted magnetic interference from other systems, and an outer jacket insulation. The center conductor signal is applied to an amplifier to operate the indicator.

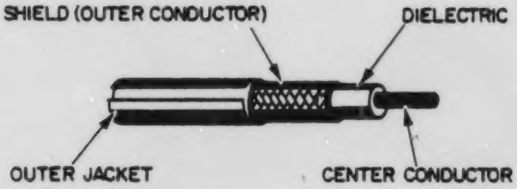


Figure 18.

Circle the letters of the correct responses to the following statements.

1. The COAX lead carries the signal from the

   a. tank unit to the amplifier.
   b. indicator to the amplifier.
   c. compensator to the amplifier.

2. The COAX lead is shielded to prevent

   a. static interference in the radio.
   b. a magnetic buildup around the conductor.
   c. induction of electrical signals to the center conductor.

Answer to Frame 17: 1. a

910

Frame 19

The outer tube (plate) is a seamless tube coated with a thick Zapan insulating finish which prevents short circuits and grounding. The inner and outer plates are spaced and insulated from each other by plastic spacers. At one end of the unit is a fixed insulator and a mounting spring which provides vibration isolation and support. In addition, the unit may have movable insulators and mounting springs fitted around the outer electrode to permit clamping of the unit to a suitable mounting bracket. See figure 19 below for a view of the outer plate. There is an unshielded lead attached to the outer tube (plate) of the tank unit and is called a GEON lead. This GEON lead carries the operating voltage from the bridge circuit to the tank units.

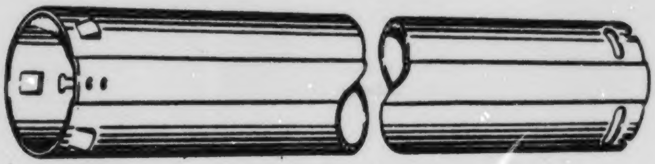


Figure 19.

Circle the letter of the correct responses to the following statements.

1. The purpose of the Zapan coating is to

   a. conduct current through the outer electrode.
   b. prevent short circuits and grounding.
   c. conduct current through the inner electrode.

2. The GEON lead carries voltage from the

   a. amplifier to the tank unit.
   b. bridge circuit to the tank unit.
   c. empty potentiometer to the tank unit.

Answers to Frame 18: 1. a 2. c

Another component, the tank unit compensator is a light weight, internally mounted sensing element that is usually attached to the lowest part of the tank unit probe in the lowest part of the tank. See figure 20 below. The compensator is placed in this arrangement to make sure it will be covered with fuel at all times so that the K factor changes will be corrected for. The compensator unit itself consists of 3 concentric tubes separated by insulated spacers. The center tube forms one plate and the internal and external tubes are tied together to form the other plate. See figure 21 below. The compensator is then connected in parallel to the reference capacitor of the intermediate device to oppose current flow from the tank units.

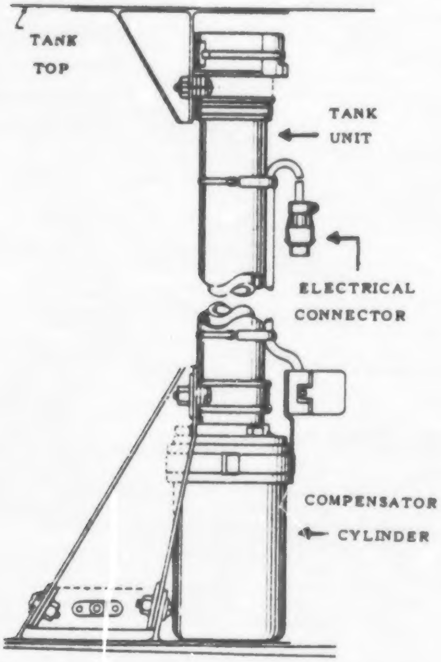

TANK TOP
TANK UNIT
ELECTRICAL CONNECTOR
COMPENSATOR CYLINDER

Figure 20.

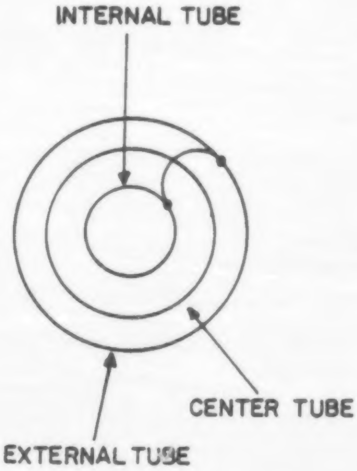

INTERNAL TUBE
CENTER TUBE
EXTERNAL TUBE

Figure 21.

Circle the letter of the correct response to the following statements.

1. The compensator is mounted

   a. at the top of the tank.
   b. in the middle of the tank.
   c. at the lowest part of the tank.

Frame 20 (Cont'd)

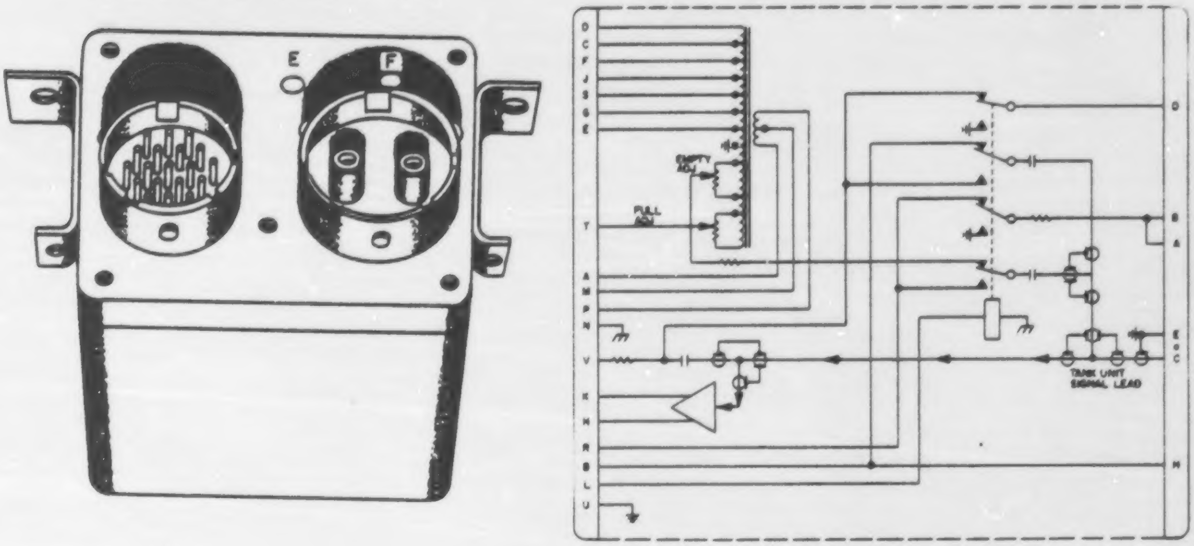
2. Current flow through the compensator

   a. aids tank unit current flow.
   b. opposes tank unit current flow.
   c. does not affect tank unit current flow.

Answers to Frame 19: 1. b 2. b

Frame 21

The Intermediate Device (figure 22 below) is the "heart" of the Capacitance Quantity Indicating System. This component supplies the operating voltages to the tank unit probes, converts the capacitance signals from the tank units into a driving signal to operate the indicators, contains all the adjustments of the system, and supplies all signals during the self-test of the system. One intermediate device is needed for each of the four systems and all of the intermediate devices are interchangeable so that only calibration is needed after installation.



A
External View

B
Internal View

Figure 22.

Circle the letter of the correct response to the following statements.

1. The unit that converts the capacitance signals into driving signals is the

   a. tank unit probes.
   b. reference capacitor.
   c. intermediate device.
   d. indicator.

Answers to Frame 20: 1. c 2. b

Frame 22

The driving signals from the four intermediate devices operate two servo-motor driven indicators. Both indicators are lighted by internal lighting. The first indicator (shown in figure 23) is the Fuselage Fuel Indicator which displays the fuel quantity of the forward and aft fuel tanks by the use of two points. The forward tank "F" pointer and the aft tank "A" pointer are read against a dia from 0 to 20 X 1000 pounds.

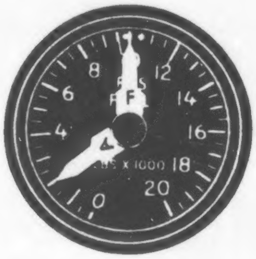


Figure 23.

Circle the correct answer to the following statement.

1. The Fuselage Fuel Indicator displays the amount of fuel in the Forward and Aft tanks in

   a. gallons X 100.
   b. pounds X 100.
   c. gallons X 1000.
   d. pounds X 1000.

Answer to Frame 21: 1. c

Frame 23

The fuselage fuel indicator is also used to control the center of gravity of the aircraft or Fuel Distribution of the aircraft. The mechanisms of the two indicators are coupled through a differential gear arrangement and a group of cam operated switches. See figure 24 below. When the ENG FEED switch is rotated to AUTO, this group of switches controls fuel relays that will either open or close fuel valves allowing fuel to transfer from the aft tank to the forward tank. This will maintain the center of gravity until the aft tank is empty.

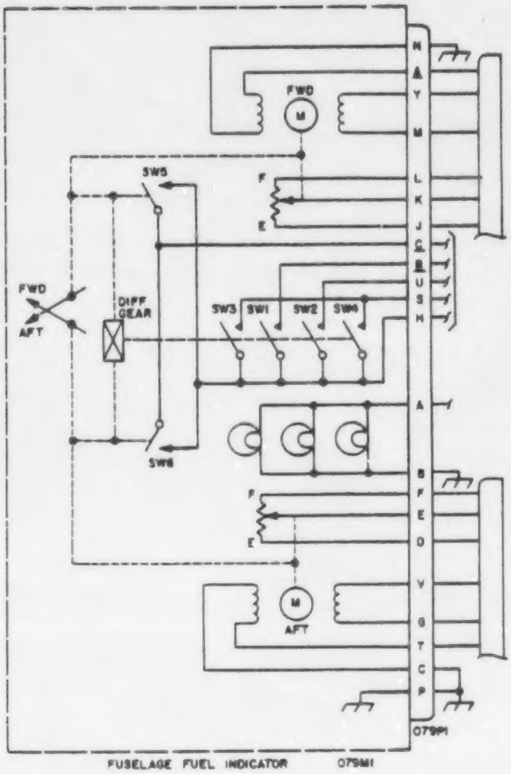

N
A
Y
M
FWD
M
SW5
F
E
L
K
J
C
B
U
S
H
FWD
AFT
DIFF GEAR
SW3
SW1
SW2
SW4
A
SW6
B
F
E
D
F
E
V
M
AFT
G
T
C
P
079P1
FUSELAGE FUEL INDICATOR
079M1

Figure 24.

Circle the letter of the correct responses to the following statements.

1. The differential gear and switching arrangement shown above controls fuel flow between the
   - a. forward and aft tanks.
   - b. forward tank and the engines.
   - c. aft tank and the engines.
   - d. wing tanks and the engines.

Answer to Frame 22: 1. d

916

Frame 24

A fuel distribution caution light is located on the main instrument panel. This light is controlled by various switches in the fuselage fuel indicator. The light is used to warn the pilot that the fuel distribution system has failed and the center of gravity of the airplane is shifting. The caution lamp lights when the indicated fuel differential between the forward and aft tanks is less than 7600 (±200) pounds or more than 10,000 (±200) pounds. The lamp is operable only when the engine feed switch is positioned to AUTO and then only when the forward tank indication is greater than appoximately 8,000 pounds or when the aft tank indication is greater than 225 pounds.

Circle the letter of the correct responses to the following statements.

1. The fuel distribution caution light is used to warn the pilot that the fuel distribution system has failed and that the

   a. right wing is becoming heavy.
   b. left wing is becoming heavy.
   c. center of gravity is changing.

Answer to Frame 23: 1. a

Frame 25

If an aft center of gravity condition occurs, and the normal system fails to operate, a backup system will energize the fuel distribution caution lamp, with the engine feed switch in any operating position. The backup distribution system consists of a fuel distribution monitor control unit, and four thermistor type sensors. These sensors are installed on the tank units. See figure 25 below.

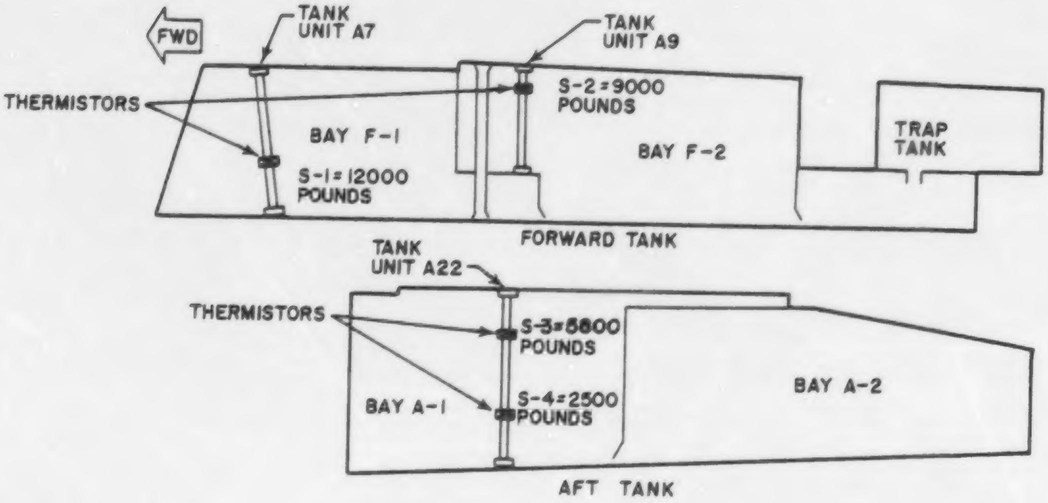

FWD
TANK UNIT A7
TANK UNIT A9
THERMISTORS
S-2=9000 POUNDS
BAY F-1
BAY F-2
TRAP TANK
S-1=12000 POUNDS
FORWARD TANK
TANK UNIT A22
THERMISTORS
S-3=5800 POUNDS
BAY A-2
BAY A-1
S-4=2500 POUNDS
AFT TANK

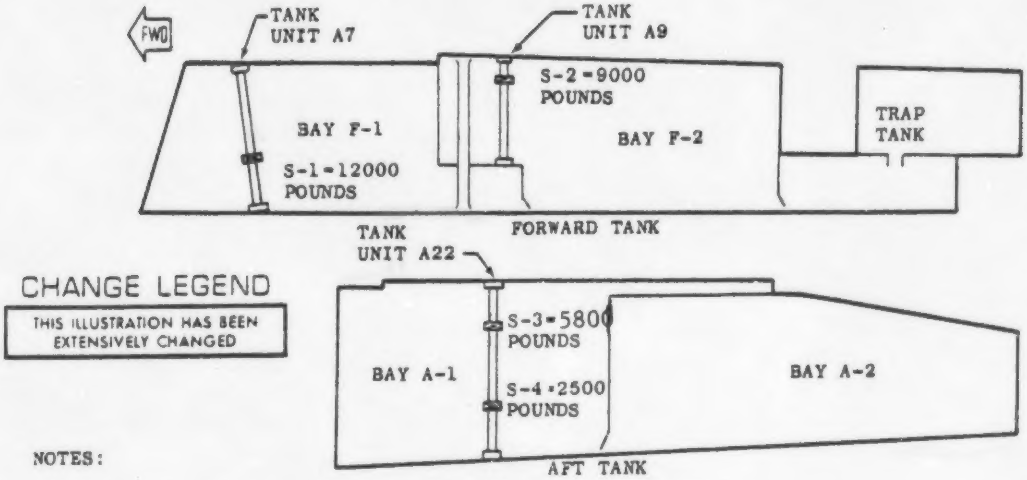
Figure 25.

NO RESPONSE REQUIRED

Answer to Frame 24: 1. c

Frame 26

When the normal distribution caution system fails to operate at a fuel differential of 7600 pounds, this backup system will cause the FUEL DISTRIB caution lamp to light when the fuel differential decreases to approximately 6500 to 6700 pounds. This system will operate with the engine feed switch in any position. If this condition exists when the ENG FEED switch is in the AUTO position, the part of the automatic CG control circuit that controls the aft tank booster pumps is disabled. This protects against failure of the automatic CG circuit that would turn off the aft booster pumps and result in an abnormal aft CG. The logic circuitry contained in the distribution monitor control unit will provide an output only under conditions shown in figure 26 below.


FWD
TANK UNIT A7
TANK UNIT A9
S-2 = 9000 POUNDS
BAY F-1
BAY F-2
TRAP TANK
S-1 = 12000 POUNDS
FORWARD TANK
TANK UNIT A22
CHANGE LEGEND
THIS ILLUSTRATION HAS BEEN EXTENSIVELY CHANGED
S-3 = 5800 POUNDS
BAY A-1
BAY A-2
S-4 = 2500 POUNDS
AFT TANK

NOTES:

1. FUEL QUANTITIES (POUNDS) GIVEN IN DRAWING, DENOTES THE INDICATION OF FUS FUEL INDICATOR AT WHICH SENSORS ARE WETTED
2. THE FUEL DISTRIBUTION CAUTION SYSTEM PROVIDES AN OUTPUT TO THE FUEL DISTRIBUTION CAUTION LIGHT UNDER THE FOLLOWING CONDITIONS ONLY
   S1 DRY AND S3 WET (FWD 12,000, AFT 5,800) LIGHT "ON"
   OR
   S1 AND S2 DRY AND S4 WET FWD 9,000, AFT 2,500) LIGHT "ON"
3. NO OTHER COMBINATION OF WET AND DRY SENSORS SHALL RESULT IN AN OUTPUT TO THE CAUTION LIGHT.

Figure 26.

The quantity levels specified are indicated values and will vary with airplane attitude.

Refer to figure 26 above and circle the letter of the correct responses to the following statements.

1. The fuel distribution caution system provides an output to the fuel distribution caution light with

   a. S1 wet and S3 dry (fwd 12,000, aft 5,800) light on.
   b. S1 dry and S3 wet (fwd 9,000, aft 2,500) light on.
   c. S1 dry and S3 wet (fwd 12,000, aft 5,800) light on.
   d. S1 and S2 dry and S4 wet (fwd 12,000, aft 5,800) light on.

Frame 27

A time delay circuit in the control unit prevents erratic operation of the FUEL DISTRIB caution lamp that may be caused by fuel slosh and/or aircraft maneuvers. A fuel differential between the forward and aft tank less than 6500 - 6700 pounds must exist for 12.5 (±2.5) seconds before the FUEL DISTRIB caution lamp will light. If the caution lamp lights, it will remain lit for 12.5 (±2.5) seconds after the abnormal aft CG condition ceases to exist.

Circle the letter of the correct responses to the following statements.

1. The thing that prevents irregular operation of the FUEL DISTRIB caution lamp is a

   a. fuel differential between the forward and aft tanks.
   b. a time delay circuit in the control unit.
   c. restriction of fuel slosh between the forward and aft tanks.

Answer to Frame 26: 1. c

Frame 28

The second indicator (figure 27) is the Select/Total Indicator which displays the fuel quantity of the select tanks and the total fuel in all of the tanks. The Select indication is a pointer read against a dial from 0 - 5 X 1000 pounds and the total indication is a drum-type digital readout of the total amount of fuel aboard the aircraft. The Select indication is controlled by a 9 position rotary switch (figure 28) called the Fuel Gage Select Switch. By placing the switch to the different positions, a different tank's amount of fuel will be displayed by the Select pointer.

SELECT AND TOTAL
FUEL INDICATOR

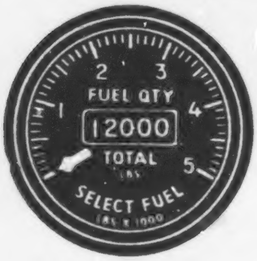
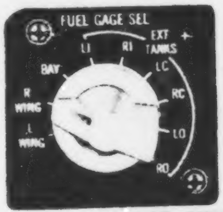


Figure 27.



FUEL GAGE SELECT SWITCH

Figure 28.

Circle the letter of the correct response to the following statements.

1. The drum-type digital readout is used to display which of the following indications?

   a. Forward tank
   b. Aft tank
   c. Select tank
   d. Total

2. The unit used to check the amount of fuel on the select portion of the fuel quantity indicator is the

   a. intermediate devices.
   b. tank simulator relay.
   c. four totalizer test switches.
   d. fuel gage select switch.

Answer to Frame 27: 1. b

Frame 29

A tank simulator relay is used to provide an empty capacitance for the totalizer circuit when the external tanks or bay tanks are not installed. The reason it is used to keep the total fuel quantity reading accurate when the above mentioned tanks are not installed. The relay is permanently mounted and deactivated whenever the bay tanks or external tanks are installed. See figure 29.

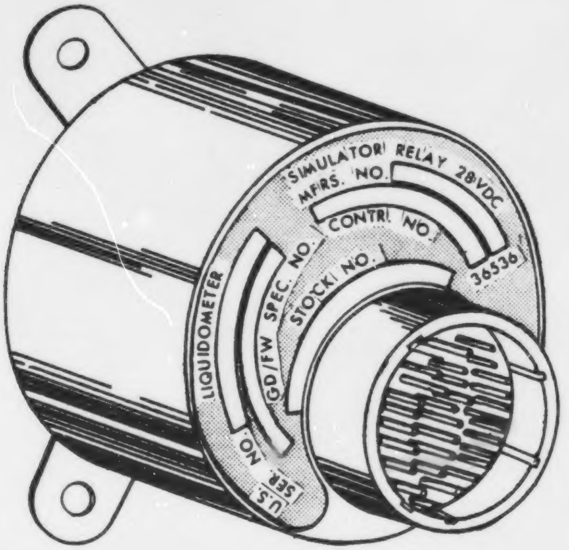

SIMULATOR RELAY 28VDC
MFRS. NO.
CONTR. NO.
36536
STOCK NO.
SPEC. NO.
GD/FW
LIQUIDOMETER
U.S. SER. NO.

Figure 29.

Circle the letter of the correct responses to the following statements.

1. The unit used to simulate an empty tank when the external tanks or bay tanks are not installed is the

   a. intermediate device.
   b. tank simulator relay.
   c. tank compensating unit.
   d. four isolation switches.

Answers to Frame 28: 1. d 2. d

Frame 30

The total fuel quantity system also uses a switch referred to as the totalizer test switch. This switch is used in troubleshooting the system. It has four toggle switches labeled FWD, AFT, L. WING and R. WING. See figure 30 below for a schematic of the switches. Using a TF 20-1 capacitance tester connected to the tank circuit at the total intermediate device, you can actuate three switches and measure the amount of capacitance remaining in the circuit. This is accomplished by eliminating the capacitance of the three circuits not being tested. As an example, when the FWD, AFT, and LW switches are actuated, the capacitance readout on the tester should equal the capacitance of the right wing. The test switches will NOT check the drop tank circuits.

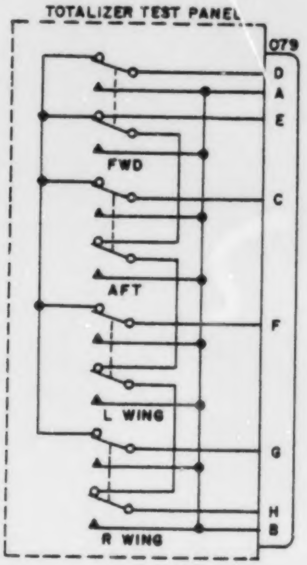


Figure 30.

Circle the letter of the correct responses to the following statements.

1. When the totalizer test switches, RW, LW and AFT are activated the capacitance read out should be the capacitance of the

   a. RW tank.
   b. LW tank.
   c. AFT tank.
   d. FWD tank.

Answer to Frame 29: 1. b

924

Frame 31

The last component is the Fuel Gage Test Switch. See figure 31 below. This switch when depressed causes all four indications on the indicators to drive to 2,000 pounds. This is done by a relay in each intermediate device. With the switch depressed the relay energizes and removes the capacitance signal of the probes from the amplifier. Then predetermined signals are sent to the indicators from the intermediate device to drive the indication to 2,000 pounds.

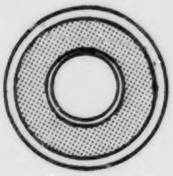


Figure 31

NO RESPONSE REQUIRED

915

Answer to Frame 30: 1. d

As you have seen, the capacitance quantity indicating system is large and complicated, and requires very reliable test equipment to ensure the system functions properly. The TF 20-1 Capacitance Test Set is the tester designed to fill this role. Refer to figure 32 on page 38 for a view of the TF 20-1 capacitance tester.

The TF 20-1 test set contains four basic circuits. Each circuit performs a separate function. The four circuits are for:

1. Measuring tank unit probe capacitance.
2. Measuring tank unit insulation resistance.
3. Simulating the total capacitance of a probe for checking the aircraft indicator under test.
4. System calbration.

The test set includes simple circuits and the highest grade components to obtain excellent stability and accuracy. The capacitance indicator and the megohmmeter scale on the test set are hermetically sealed. The reference capacitors in the capacitance measuring circuit are hermetically sealed after adjustment at the factory. All transformers are potted to prevent corrosion.

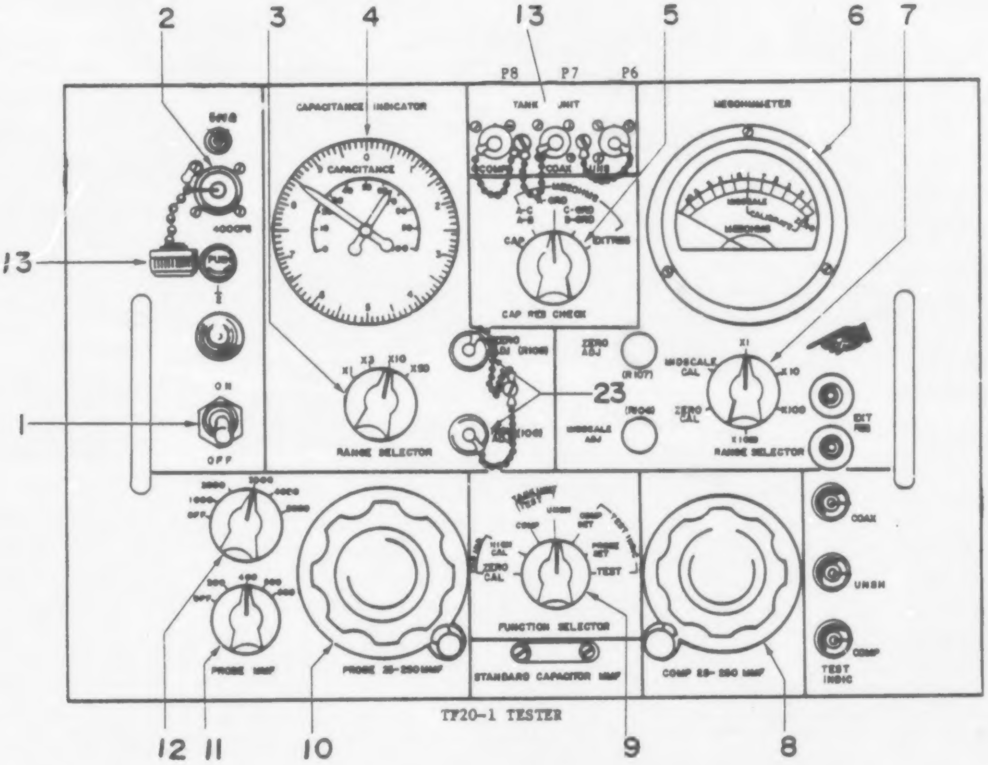
Circle the letter of the correct response for the following statements.

1. The tester used to check out the capacitance quantity indicating system is the

   a. TTU 205/CE.
   b. PSM-6.
   c. TF 20-1.
   d. N3A.

2. The reference capacitors are adjusted

   a. at the factory.
   b. before each use.
   c. during the capacitance measurement.


2
3
4
13
5
6
7
P8
P7
P6
CAPACITANCE INDICATOR
TANK UNIT
MEGOHMMETER
CAPACITANCE
400CPS
13
ON
OFF
1
COMP
COAX
UNSH
CAP
CAP RES CHECK
MIDSCALE
MEGOHMS
X1
X3
X10
X30
RANGE SELECTOR
ZERO ADJ
(R107)
MIDSCALE ADJ
23
MIDSCALE CAL
ZERO CAL
X10
X100
X1000
RANGE SELECTOR
EXT RES
COAX
UNSH
COMP
TEST INDIC
ZERO CAL
FUNCTION SELECTOR
TEST
STANDARD CAPACITOR MMF
PROBE MMF
PROBE 25-250 MMF
COMP 25-250 MMF
TF20-1 TESTER
12
11
10
9
8

1. ON-OFF SWITCH
2. 115V 400 CPS RECEPTACLE
3. CAPACITANCE RANGE SELECTOR
4. CAPACITANCE INDICATOR
5. CAP-RES CHECK SELECTOR
6. MEGOHMMETER
7. MEGOHMMETER RANGE SELECTOR
8. COMPENSATOR CAPACITOR KNOB
9. FUNCTION SELECTOR
10. PROBE CAPACITOR KNOB
11. PROBE UUF HUNDREDS KNOB
12. PROBE UUF THOUSANDS KNOB
13. PROTECTIVE CAPS (6)

Figure 32. TF 20-1 Capacitance Test Set.

Frame 33

In frame 1, we stated that basically the liquid oxygen (LOX) system operation is the same as fuel quantity. This is true as it uses a variable capacitor probe (sensor) mounted in an oxygen converter to sense the amount of liquid oxygen and sends this signal to the indicator. The indicator amplifies the signal to drive the pointer. System range is 0 to 20 liters and requires 115 VAC, 400 hertz, 1 phase power for operation. When LOX capacitance is down to approximately 2 liters a low level warning lite comes on. See figure 33 below.

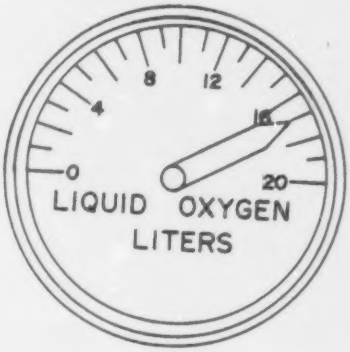


Figure 33.

Circle the letter of the correct response to the following statements.

1. To sense the amount of liquid oxygen the LOX system uses a

   a. variable resistance probe.
   b. oxygen converter.
   c. variable capacitor probe.
   d. fixed capacitor probe.

2. The range of the LOX system is

   a. 0 to 20 liters.
   b. 0 to 25 liters.
   c. 0 to 30 liters.
   d. 0 to 35 liters.

3. A low level warning lite comes on when the LOX capacitance is down to approximately

   a. 1 liter.
   b. 2 liters.
   c. 4 liters.
   d. 6 liters.

Answers to Frame 32: 1. c 2. a

When the press-to-test switch on the caution panel is depressed, the indicator drives to below 0 (off scale empty). The low level lite comes on at approximately 2 liters and will remain on until the press-to-test switch is released and the indicator reaches approximately 4 liters. This is the self test for system operation and requires 28 VDC power. See figure 34.

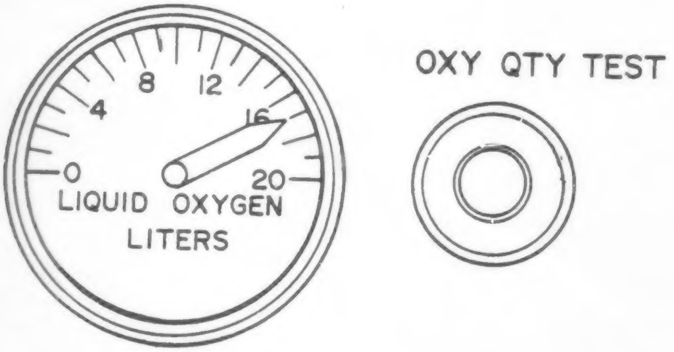


Figure 34.

Circle the letter of the correct responses to the following statements.

1. When the press to test switch is depressed the indicator drives to
   a. 0 liters.
   b. off scale full.
   c. off scale empty.
   d. 20 liters.

2. When the press to test switch is released the low level lite goes out at approximately
   a. 0 liters.
   b. 2 liters.
   c. 4 liters.
   d. 6 liters.

3. Self test for the LOX system requires
   a. 115 VAC.
   b. 115 VAC, 400 hertz, and 1 phase.
   c. 28 VDC.
   d. 28 VAC.

Answers to Frame 33: 1. c 2. a 3. b

929

Answers to Frame 34: 1. c 2. b 3. c

Return to the front of this PT and review the objective. When you feel that you are able to achieve the objective as stated, take the appraisal.

APPRAISAL

950

WORKBOOK
3ABR32531-WB-208
3ABR32632B-WB-307

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionics Systems Specialist

F-111 CAPACITANCE INDICATING SYSTEM

13 September 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-208
3ABR32632B-WB-307

F-111 CAPACITANCE INDICATING SYSTEM

OBJECTIVES

Given a workbook and trainer, perform an inspection and operational check of the capacitance-type liquid quantity indicating system with a minimum of 100% correct workbook responses.

Given a workbook, test equipment and trainer, troubleshoot the capacitance-type liquid quantity indicating system with a minimum of 100% correct workbook responses.

Given a workbook, test equipment, and trainer, bench check components and calibrate the capacitance liquid quantity indicating system with an accuracy of 100% correct workbook responses.

EQUIPMENT

	Basis of Issue
3ABR32531-WB-208/3ABR32632B-WB-307	1/2 students
Trainer, F-111 Fuel Quantity	1/2 students
Tester, TF20-1	1/2 students
Multimeter	1/2 students
3ABR32531-HO-208/3ABR32632B-HO-307	1/2 students

PROCEDURE

This workbook is divided into FOUR PARTS (1, 2, 3 & 4). After completing each part, check with your instructor so he can verify that your answers are correct. Read ALL steps carefully, make the appropriate response in the blank spaces provided.

Caution: Remove ALL JEWELRY before operating equipment.

Part 1. VISUAL INSPECTION

Have your instructor assign you a trainer and complete the following:

1. Inspect the Fuselage Fuel Quantity Indicator for

	S	U
a. cracked or loose glass.	_____	_____
b. condition of pointers.	_____	_____
c. security of mounting.	_____	_____

Supersedes 3ABR32531-WB-213, 3ABR32632B-WB-305, 5 January 1976, which may be used until existing stocks are exhausted.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 300; TTVSR - 1

	S	U
2. Inspect the Total/Select Fuel Quantity Indicator for		
a. cracked or loose glass.	______	______
b. condition of pointer.	______	______
c. condition of drum-type counter.	______	______
d. security of mounting.	______	______
3. Inspect the Intermediate Devices for		
a. security of mounting	______	______
4. Inspect the electrical wiring for		
a. bent or damaged electrical connector plugs.	______	______
b. scorched or broken insulation.	______	______
c. frayed or broken wires and bonding.	______	______
d. loose or broken ties (string).	______	______

Instructor's Initials ______________

Part 2. OPERATIONAL CHECK

1. Perform an operational check of the Fuel Quantity Indicating System as follows:

a. Make sure ALL trouble switches located on the right side PANEL are in the OUT position. Connect trainer to 115V AC, 400 Hz and 28V DC OUTLET (drop cords).

b. CLOSE ALL four (4) DRAIN valves. Drain valves are at the bottom of trainer.

c. OPEN ALL four (4) FILL valves, and place the AC and DC power switches to the ON position.

d. Place the FUEL TRANSFER PUMP switch to the ON position, and allow tanks to FILL. As each tank reaches 1/2 FULL, CLOSE its FILL valve.

e. When ALL four (4) fuel tanks are 1/2 FULL, PLACE the FUEL TRANSFER switch to the OFF position. Adjust DRAIN valves so ALL tanks read 1/2 FULL.

f. Place the two (2) forward and aft EMPTY/FULL switches located between TANK PROBES, to the FULL position. This makes ALL INDICATORS read FULL for the PARTICULAR TANK.

g. Turn the FUEL GAGE SEL switch to LEFT WING and the RIGHT WING positions and READ and RECORD both switch positions of the SELECT GAGE (M2).

(1) Read and record LEFT WING and RIGHT WING fuel from the SELECT and TOTALIZER GAGE (M2) L.W. ______

R.W. ______

(2) Read and record FWD (F) and AFT (A) fuel from the FUSELAGE GAGE (M-1). FWD ______

AFT ______

(3) Total ALL the above gage readings. SUM ______

(4) TOTALIZER (M-2) Reads. TOTAL ______

(5) Tolerance is ± 1,000 pounds (difference)DIF ______

(6) Indicate if Sat. _____ or Unsat. _____.

Note: If satisfactory, continue on to the next STEP and if not, check with the instructor for an explanation.

h. Hold the PRESS-TO-TEST switch (S1) "IN" and observe and RECORD the NORMAL SYSTEMS FUNCTIONS CHECK.

(1) TOTALIZER drives to 2,000 lbs ± 1250

TOT __________ S ______ U ______

(2) SELECT drives to 2,000 lbs ± 100

SEL __________ S ______ U ______

(3) FWD drives to 2,000 lbs ± 400

FWD __________ S ______ U ______

(4) AFT drives to 2,000 lbs ± 400

AFT __________ S ______ U ______

Instructor's Initials __________________

Part 3. TROUBLESHOOTING

1. The instructor will assign six or more problems (switch numbers) for troubleshooting. Follow instructions below for indications and location of trouble.

a. Using CHART 1, the student will place ONE trouble switch IN at a time and observe the INDICATORS for a MALFUNCTION and LOCATION of trouble.

b. If a MALFUNCTION occurs, list it in trouble indication column, then PRESS-TO-TEST switch (S1). If the indications on the INDICATOR(s) change, the trouble is on the PROBE SIDE of the INTERMEDIATE DEVICE.

c. If NO MALFUNCTION occurs, PRESS-TO-TEST switch (S1) and observe INDICATOR(s) for a change in reading(s). If nothing happens (inoperative), the trouble is on the power side of the INTERMEDIATE DEVICE for the particular INDICATOR(s).

d. After recording indication for ONE trouble, place trouble switch to OUT and WAIT until indications come back to NORMAL, then place in next trouble switch.

e. Record trouble indication, then press (S1) and record location of trouble.

Note: With (S1) pressed, INDICATOR(s) fail to respond -- Power (PWR) side. With (S1) pressed, INDICATOR(s) indicate approximately 2,000 lbs -- PROBE SIDE.

SW #	TROUBLE INDICATION	Trouble Location	Wire Number	Kind of Trouble
		PROBE SIDE or PWR SIDE		SHORT OR OPEN

CHART 1.

f. After verification by the instructor, THEN and only THEN will you turn BOTH power switches to OFF.

(1) Remove the power cables from the power OUTLETS and secure cables to the TRAINER.

(2) Open ALL DRAIN and FILL valves to drain ALL tanks.

(3) Place the forward and aft EMPTY/FULL switches to the EMPTY position.

Note: Before attempting any troubleshooting, read paragraphs 2 through 13g.

2. Follow instructions BELOW to help you troubleshoot the system.

a. Read trouble malfunction.

b. Refer to internal circuit of components, figures 1, 2, and 3 as an aid when using the wiring diagram.

c. Use trouble locations to minimize the amount of time needed to troubleshoot.

d. Use wiring diagram 3ABR32531-WB-208/307 and use the multimeter.

TROUBLE MALFUNCTIONS

3. The following malfunctions are NORMALLY caused by OPEN or SHORTED wiring in the circuit.

a. Fuel quantity indicator READS higher than normal.

(1) Open compensator or SHORTED compensator lead to ground.

(2) SHORTED inner conductor to the shielded wire or to ground (inner to outer).

4. Fuel quantity reads LOWER than normal or against the EMPTY STOP, depending on amount of fuel.

a. OPEN low impedance (Geon) lead.

b. OPEN high impedance (shielded) lead.

5. Fuel quantity reads against the EMPTY STOP.

a. SHORT to ground of low impedance (Geon) lead.

If NO indication in the system, push-to-test switch and NOTE malfunction.

6. When S1 is pressed and INDICATOR(S) show NO response (inoperative), this is caused by:

a. OPEN power, signal or ground lead to indicators.

7. Start troubleshooting at INTERMEDIATE DEVICES.

8. Refer to above malfunctions and use figures 1, 2, 3, and wiring diagram.

OHMMETER TROUBLESHOOTING

9. Obtain a multimeter, place on rack of trainer that has connectors unplugged. Use wiring diagram and trouble switches.

10. Acft troubleshooting: Power panel to intermediate device.
Probe side -- Intermediate device to tank units.
Power side -- Intermediate device to indicators.

11. On F-111 trainer, start troubleshooting at intermediate device. Note: A capital letter with a line under it (A̲) is a small letter.

12. Call instructor: Instructor will explain acft troubleshooting, location of trouble and trace a wire from intermediate device to tank unit.

13. Follow instruction BELOW for troubleshooting.

a. Turn ON applicable trouble switch.

b. Refer to TROUBLE MALFUNCTIONS to determine the probable troubles.

c. Refer to CHART #1 for trouble indications and LOCATION of trouble.

d. Locate the correct INTERMEDIATE DEVICE on the wiring diagram.

e. Locate kind of trouble and list WIRE NUMBER(S).

f. ONE student tells where to check and the OTHER student used ohmmeter to find trouble.

g. Change jobs (positions).

14. After completing the troubleshooting exercise, INSURE that ALL trouble switches are in the OUT position. At this time give the workbook to the instructor so that he can VERIFY your troubleshooting, etc.

Instructor's Initials ________________

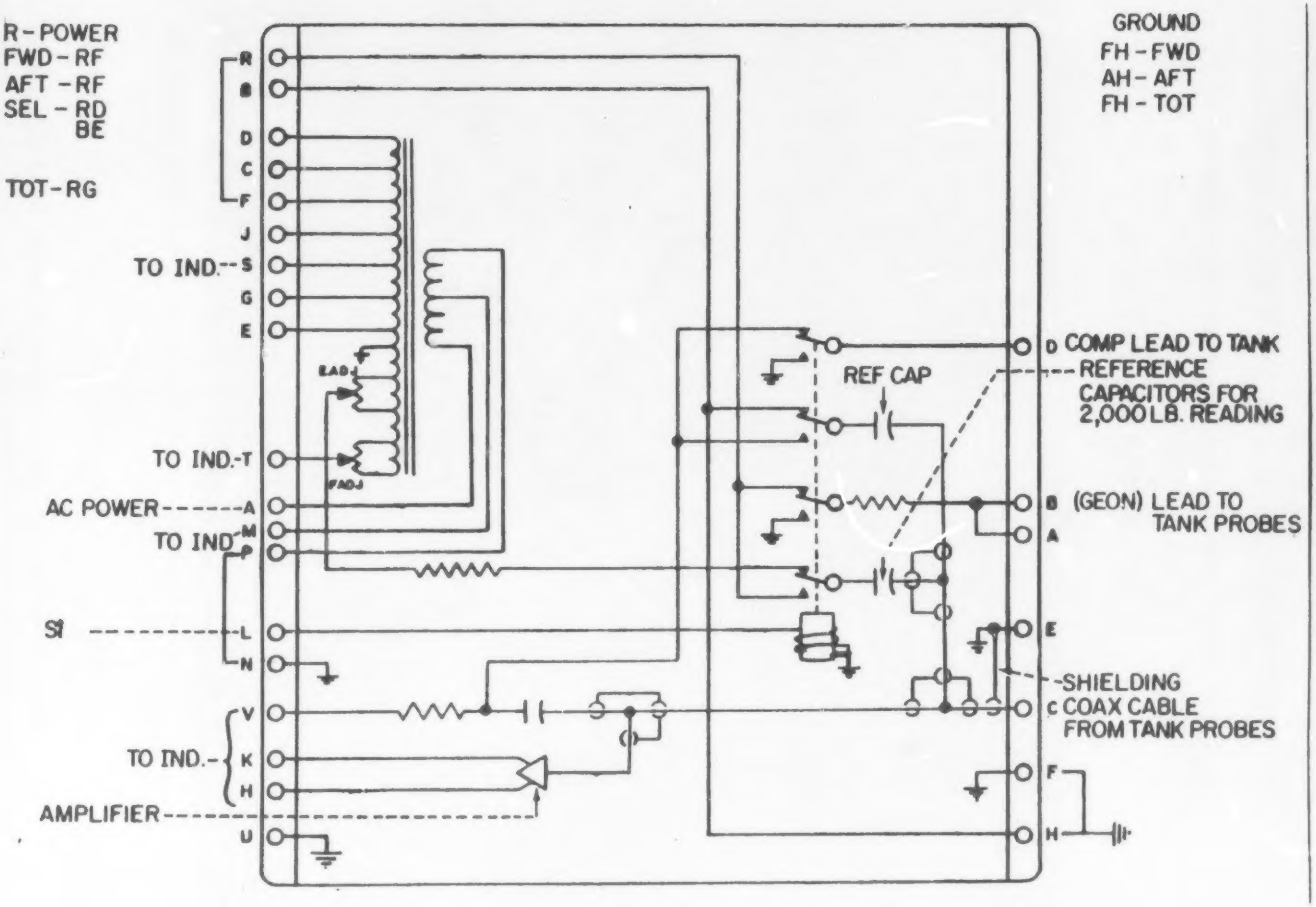
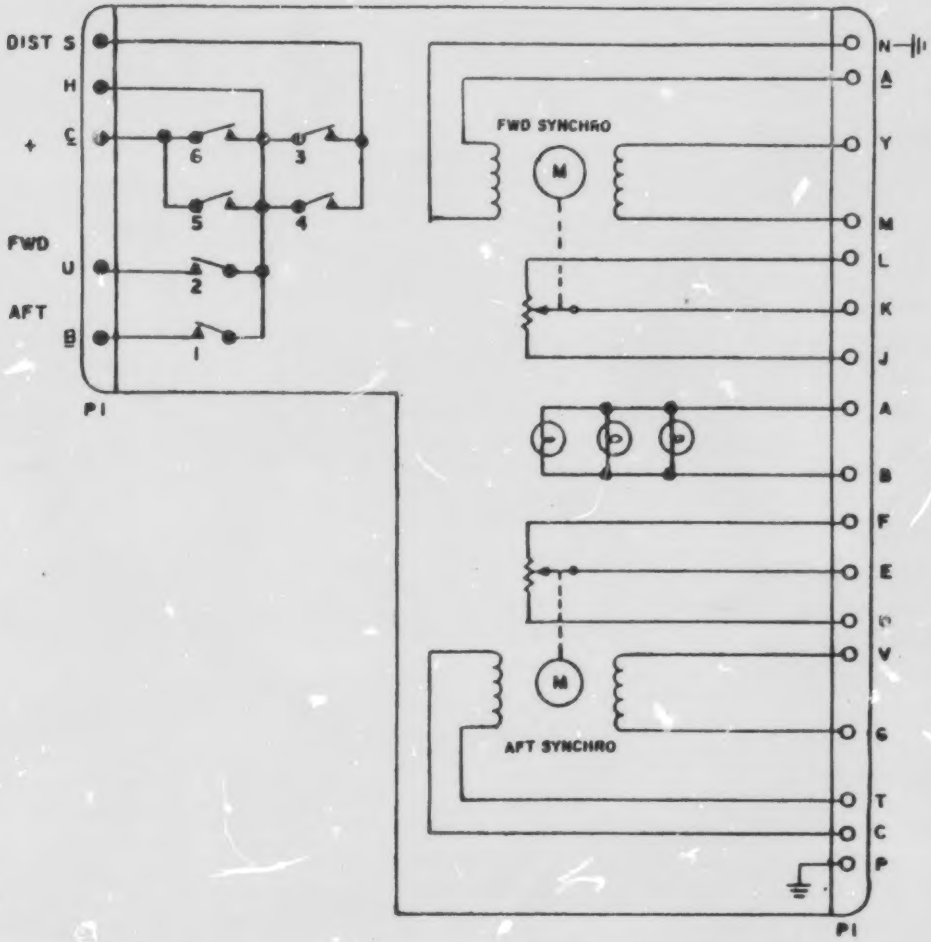

R-POWER
FWD-RF
AFT-RF
SEL-RD
BE
TOT-RG
GROUND
FH-FWD
AH-AFT
FH-TOT
R
B
D
C
F
J
TO IND.--S
G
E
EADJ
FADJ
TO IND.-T
AC POWER------A
TO IND M
P
SI
L
N
V
TO IND.- K
H
AMPLIFIER
U
D COMP LEAD TO TANK
REF CAP
REFERENCE CAPACITORS FOR 2,000 LB. READING
B (GEON) LEAD TO TANK PROBES
A
E
SHIELDING
C COAX CABLE FROM TANK PROBES
F
H

Figure 1. Intermediate Devices; FWD, AFT, SEL & TOT.

958


DIST
S
H
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3
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FWD SYNCHRO
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K
J
A
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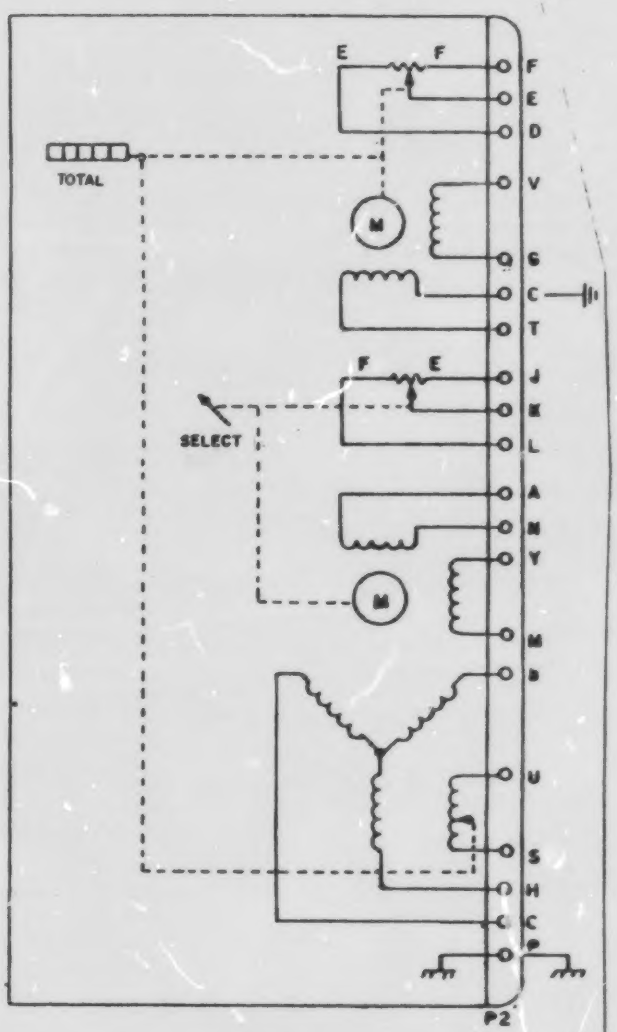
AFT SYNCHRO
T
C
P
P1

Figure 2. Fuselage Fuel Indicator. (M-1)


E
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SELECT
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N
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M
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B
U
S
H
C
P
P2

Figure 3. Select and Total Indicator. (M-2)

Part 4. CALIBRATION AND BENCH CHECK

1. Perform calibration of the TF20-1 capacitance indicator IAW the following instructions.

a. Before connecting TF20-1 tester to trainer, connect trainer to 115V AC, 400 Hz and 28V DC OUTLET. Turn trainer power ON and observe the fuselage fuel indicator's "F" (FWD) pointer for a ZERO reading. If it is NOT on zero, notify your instructor. Turn trainer power switches to "OFF."

Note: Place FWD and AFT EMPTY/FULL switches to EMPTY position.

b. To prevent erroneous capacitance measurements, trainer electrical power must not be turned on during the following checks.

Caution: Use extreme caution when connecting tester harness so as NOT to damage pins and connector plugs or wires.

Note: The power cable and test harness are already connected to the TF20-1 tester. UNDER NO circumstances will you remove the power cable or test harness from their connections on the TF20-1 tester.

c. Disconnect the large connector plug from the right side of the forward intermediate device on the trainer. Connect the TF20-1 test cable W1P1 to the male fitting on the forward intermediate device. Connect the TF20-1 test cable W1P2 to thy female fitting on the trainer harness.

d. Connect the TF20-1 power cable to the 115V AC 400 Hz power OUTLET plug.

Note: Do NOT apply power to trainer at this time.

e. Place the TF20-1 power switch to the ON position.

Note: If power switch is turned OFF on TF20-1 tester, tester must be recalibrated.

f. Position CAP-RES-CHECK selector to CAP position. (Selector should stay in CAP position throughout calibration procedures.)

g. Position FUNCTION SELECTOR to ZERO CAL.

h. Position capacitance indicator RANGE SELECTOR to X1.

RESULT: Pointer of capacitance indicator should indicate zero plus or minus .1 PF. If capacitance indicator reads ZERO, proceed to substep j. If it does NOT read ZERO, proceed to substep i.

i. Remove the CAP from the ZERO ADJUST control for the CAPACITANCE INDICATOR and adjust the ZERO control until the pointer on the CAPACITANCE INDICATOR indicates ZERO, plus or minus .1 PF.

j. Place the CAPACITANCE INDICATOR RANGE SELECTOR to X10.

k. Place the CAPACITANCE INDICATOR FUNCTION SELECTOR to HIGH CAL.

RESULT: Pointer of CAPACITANCE INDICATOR should indicate the STANDARD CAPACITOR PF stamped on the METAL PLATE located directly BELOW the FUNCTION SELECTOR to within plus or minus .1 PF.

Note: If the pointer of the CAPACITANCE INDICATOR does NOT indicate STANDARD CAPACITOR PF, remove the protective CAP from the HIGH ADJUST control and adjust the control until the pointer of the CAPACITANCE INDICATOR indicates STANDARD CAPACITANCE PF.

l. Repeat substeps g through k until no further adjustment is necessary. Replace CAPS on the ZERO ADJUST and HIGH ADJUST controls.

Note: Recheck for ZERO CAL and HIGH CAL.

m. Position FUNCTION SELECTOR to UNSHIELD position.

n. Record the exact capacitance indicator readings of the forward tank below. Dry capacitance reading shall be 768.7 to 784.2 PF.

The dry capacitance reading is ____________ PF.

(1) Forward tank capacitance dry reading bench checked satisfactory _____, unsatisfactory _____.

o. Position FUNCTION SELECTOR to COMP.

p. Position CAPACITANCE INDICATOR RANGE SELECTOR to X1.

q. RECORD the exact capacitance indicator reading of the forward tank compensator below. Dry capacitance reading shall be 27.9 to 33.0. Dry capacitance reading is __________ PF.

(1) Forward tank compensator bench checked satisfactory _____, unsatisfactory _____.

2. Forward Tank Fuel Quantity Calibration (DRY TANK).

Note: Calibration procedures for the TF20-1 CAPACITANCE INDICATOR must be accomplished prior to each dry capacitance measurement unless otherwise stated. Configuration of switches (selectors, controls, etc.) in the following procedures are to be performed on the TF20-1 test set.

a. Turn trainer power ON.

b. Position FUNCTION SELECTOR to ZERO CAL.

c. Position CAPACITANCE INDICATOR RANGE SELECTOR to X1.

RESULT: Pointer of CAPACITANCE INDICATOR should indicate ZERO, plus or minus .1 PF.

Note: If pointer of CAPACITANCE INDICATOR does NOT indicate zero, plus or minus .1 PF, proceed to substep d; if indication is ZERO, proceed to substep e.

d. Remove the CAP from the ZERO ADJUST control for the CAPACITANCE INDICATOR and ADJUST the control until the pointer on the CAPACITANCE INDICATOR indicates ZERO, plus or minus .1 PF.

e. Place the CAPACITANCE INDICATOR RANGE SELECTOR to X10.

f. Place the CAPACITANCE INDICATOR FUNCTION SELECTOR to HIGH CAL.

RESULT: Pointer of CAPACITANCE INDICATOR shall indicate the STANDARD CAPACITOR PF stamped on the METAL PLATE located directly BELOW the FUNCTION SELECTOR to within plus or minus .1 PF.

Note: If the pointer of the CAPACITANCE INDICATOR does NOT indicate STANDARD CAPACITOR PF, remove the protective CAP from the HIGH ADJUST control and adjust the control until the pointer of the CAPACITANCE INDICATOR indicates STANDARD CAPACITOR PF plus or minus .1 PF.

g. Repeat substeps b through f until NO further adjustment is necessary. Replace protective cap on ZERO and HIGH ADJUST control.

Note: Recheck ZERO CAL and HIGH CAL.

h. Position FUNCTION SELECTOR to COMP SET.

i. Position CAPACITANCE INDICATOR RANGE SELECTOR to X1.

j. Adjust COMP 25-250 MMF knob until CAPACITANCE INDICATOR INDICATES 54.2 PF; lock COMP 25-250 MMF knob.

k. Position FUNCTION SELECTOR to PROBE SET.

l. Position CAPACITANCE INDICATOR RANGE SELECTOR to X10.

m. Position PROBE MMF hundreds selector to 600. PROBE MMF thousands selector should be in OFF position.

n. Adjust PROBE 25-250 MMF knob until CAPACITANCE INDICATOR indicates 77.4 (on X10 scale, 77.4 equal 774.0 PF).

o. Position FUNCTION SELECTOR to TEST.

p. Adjust PROBE 25-250 MMF knob, (clockwise) if necessary, to position the "F" pointer of FUS FUEL indicator on the fuel quantity trainer to precisely ZERO.

q. Position FUNCTION SELECTOR to PROBE SET.

r. Take exact CAPACITANCE INDICATOR indication for forward tank DRY VALUE, multiply X10 and RECORD. CAPACITANCE INDICATOR INDICATES ____________ PF.

Note: The values recorded may or may NOT be the same as the measured value recorded in substep n due to the tolerance of either the tester or trainer.

s. ADD forward tank DRY VALUE recorded in step r to 881.2, dividé by 50 and RECORD. For FULL, the capacitance is _________ PF.

t. Position CAPACITANCE INDICATOR RANGE SELECTOR to X50.

u. Position PROBE MMF thousands selector to 1000.

v. Position PROBE MMF hundreds selector to 600 (if not there already).

w. Adjust PROBE MMF 25-250 MMF knob for a CAPACITANCE INDICATOR indication of the recorded SET for FULL value in substep s. Lock PROBE 25-250 MMF knob and do NOT disturb this setting.

x. Position CAPACITANCE INDICATOR FUNCTION SELECTOR to TEST.

y. Observe the "F" pointer of the FUS FUEL indicator on fuel quantity trainer. When movement of the pointer ceases, the "F" pointer of the FUS FUEL indicator should be on the 20,000-pound graduation (if not, notify the instructor).

z. Turn ALL power OFF. Disconnect the TF20-1 test harness W1P1 from FWD intermediate device and harness W1P2 from trainer harness. Reconnect the trainer harness to the FWD intermediate device.

3. Aft Tank Unit Circuit and Compensator Circuit DRY Capacitance measurement.

a. To prevent erroneous capacitance measurements, electrical power must not be applied to trainer during the following checks.

CAUTION: Use extreme caution when connecting tester harness so as not to damage pins and electrical connector plugs or wires.

b. Disconnect the large connector plug from the right side of the aft intermediate device. Connect the TF20-1 test cable W1P1 to the male fitting on the aft intermediate device. Connect the TF20-1 test cable W1P2 to the female fitting on the trainer harness.

Note: DO NOT apply power to trainer at this time.

c. Place the TF20-1 power switch to the ON position.

d. Position FUNCTION SELECTOR switch to ZERO CAL.

e. Position CAPACITANCE INDICATOR RANGE SELECTOR to X1.

RESULT: Pointer of CAPACITANCE INDICATOR should indicate ZERO, plus or minus .1 PF.

Note: If pointer of CAPACITANCE INDICATOR does NOT indicate ZERO, plus or minus .1 PF, proceed to substep f; if indication is ZERO, proceed to substep g.

f. Remove the CAP from the ZERO ADJ control fo/ the CAPACITANCE INDICATOR and adjust the control until the pointer on the CAPACITANCE INDICATOR indicates ZERO, plus or minus .1 PF.

g. Place the CAPACITANCE INDICATOR RANGE SELECTOR to X10.

h. Place FUNCTION SELECTOR to HIGH CAL.

RESULT: Pointer of CAPACITANCE INDICATOR shall indicate the STANDARD CAPACITOR PF stamped on the METAL PLATE located directly BELOW the FUNCTION SELECTOR to within plus or minus .1 PF.

Note: If the pointer of the CAPACITANCE INDICATOR does NOT indicate the STANDARD CAPACITOR, remove the protective CAP from the HIGH ADJUST control and adjust control until pointer of CAPACITANCE INDICATOR indicates STANDARD CAPACITOR PF, plus or minus .1 PF.

i. Repeat substeps d through h until no further adjustment is necessary.

Note: Recheck ZERO CAL and HIGH CAL.

Caution: After the TF20-1 tester has been calibrated, DO NOT turn POWER OFF. If POWER is turned OFF, the tester has to be recalibrated.

Note: Calibration procedures for the TF20-1 CAPACITANCE INDICATOR must be accomplished prior to each DRY capacitance measurement, unless otherwise stated. Configuration of switches (selectors, controls, etc) in the following procedures are to be performed on the TF20-1 test set.

j. Position the CAPACITANCE INDICATOR RANGE SELECTOR to X10. (If NOT there already)

k. Position FUNCTION SELECTOR to UNSHIELD position.

Note: If DRY capacitance value readings noted in the following steps are NOT within the tolerances listed, recheck calibration of the TF20-1 capacitance indicator and REPEAT defective capacitance measurements before proceeding to troubleshooting.

l. Record the exact CAPACITANCE INDICATOR reading of the aft tank BELOW. DRY capacitance reading should be 388.4 PF to 405.5 PF.

DRY CAPACITANCE reading is ____________ PF.

(1) Aft tank capacitance DRY READING bench checked satisfactory _____, unsatisfactory _____.

m. Position FUNCTION SELECTOR to TANK UNIT COMP.

n. Position CAPACITANCE INDICATOR RANGE SELECTOR to X1.

o. RECORD the exact capacitance indicator reading of the AFT TANK compensator BELOW. DRY capacitance reading shall be 27.9 PF to 33.0 PF.

DRY capacitance reading is ____________ PF.

(1) AFT TANK compensator bench checked satisfactory _____, unsatisfactory _____.

p. Turn power ON to trainer and proceed with step 4.

4. AFT TANK Fuel Quantity Calibration (DRY Tank).

a. Perform calibration of the TF20-1 CAPACITANCE INDICATOR IAW the following instructions.

b. Position FUNCTION SELECTOR to ZERO CAL.

c. Position CAPACITANCE INDICATOR RANGE SELECTOR to X1.

RESULT: Pointer of CAPACITANCE INDICATOR should indicate ZERO. plus or minus .1 PF.

Note: If pointer of CAPACITANCE INDICATOR DOES NOT indicate ZERO, plus or minus .1 PF, proceed to substep d; if indication is ZERO, proceed to substep e.

d. Remove the CAP from the ZERO ADJUST control for the CAPACITANCE INDICATOR and adjust the control until the pointer of the capacitance indicator indicates ZERO, plus or minus .1 PF.

e. Place the CAPACITANCE INDICATOR RANGE SELECTOR to X10.

f. Place FUNCTION SELECTOR to HIGH CAL.

RESULT: Pointer of CAPACITANCE INDICATOR shall indicate the STANDARD CAPACITOR PF stamped on the METAL PLATE located directly BELOW the FUNCTION SELECTOR to within plus or minus .1 PF.

Note: If the pointer of the CAPACITANCE INDICATOR does NOT indicate the STANDARD CAPACITOR PF, remove the protective CAP from the HIGH ADJUST control and adjust the control until pointer of CAPACITANCE INDICATOR indicates STANDARD CAPACITOR PF plus or minus .1 PF.

g. Repeat the steps b through f until NO further adjustment is necessary. Replace protective CAP on ZERO and HIGH ADJUST controls.

h. Position FUNCTION SELECTOR to COMP SET.

i. Position CAPACITANCE INDICATOR RANGE SELECTOR to X1.

j. Adjust COMP 25-250 MMF knob, until CAPACITANCE INDICATOR indicates 54.2 PF; lock COMP 25-250 MMF knob.

k. Position FUNCTION SELECTOR to PROBE SET.

l. Position CAPACITANCE INDICATOR RANGE SELECTOR to X10.

m. Position PROBE MMF hundreds SELECTOR to 200. PROBE MMF thousands SELECTOR should be in the OFF position.

n. Adjust PROBE 25-250 MMF knob until CAPACITANCE INDICATOR indicates 39.2 PF (on X10 scale, 39.2 equals 392.0 PF).

o. Position FUNCTION SELECTOR to TEST.

p. Adjust PROBE 25-250 MMF knob, (CLOCKWISE) if necessary, to position the "A" pointer of FUS FUEL indicator on fuel quantity trainer to PRECISELY ZERO.

q. Position FUNCTION SELECTOR to PROBE SET.

r. Take exact CAPACITANCE INDICATOR indication for AFT TANK DRY value and multiply by X10 and RECORD. DRY value is ____________ PF.

Note: The values recorded in substep "n" may or may not be the same as the measured value recorded due to the tolerance of either the tester or trainer.

s. ADD AFT TANK DRY value recorded in substep "r" to 881.2 PF, divide by 50 and RECORD. DRY value is __________ PF.

t. Position CAPACITANCE INDICATOR RANGE SELECTOR to X50.

u. Position PROBE MMF thousands SELECTOR to 1000.

v. Position PROBE MMF hundreds SELECTOR to 200 (if not there already).

w. Adjust PROBE 25-250 MMF knob for a CAPACITANCE INDICATOR indication of the recorded value in substep "s." Lock PROBE 25-250 MMF knob and do not disturb this setting.

x. Position FUNCTION SELECTOR to TEST.

y. Observe the "A" pointer of the FUS FUEL indicator (M-1) on fuel quantity trainer. When movement of the pointer ceases, the "A" pointer of the FUS FUEL indicator should be on the 20,000-pound graduation (if not, notify instructor).

z. Turn ALL power switches OFF on the tester and trainer.

(1) Disconnect the TF20-1 test harness from BOTH the AFT INTERMEDIATE DEVICE and TRAINER harness.

(2) Reconnect the trainer harness to the AFT INTERMEDIATE DEVICE.

(3) The TF20-1 power cable should be disconnected from the 115V AC 400 Hz output.

(4) The power cable and test harness stored in the lid of the tester.

(5) Remove the trainer power cables from the power outlets and secure cables to the trainer.

Instructor's Initials ________________

Instrument/Flight Control Branch
Chanute AFB, Illinois

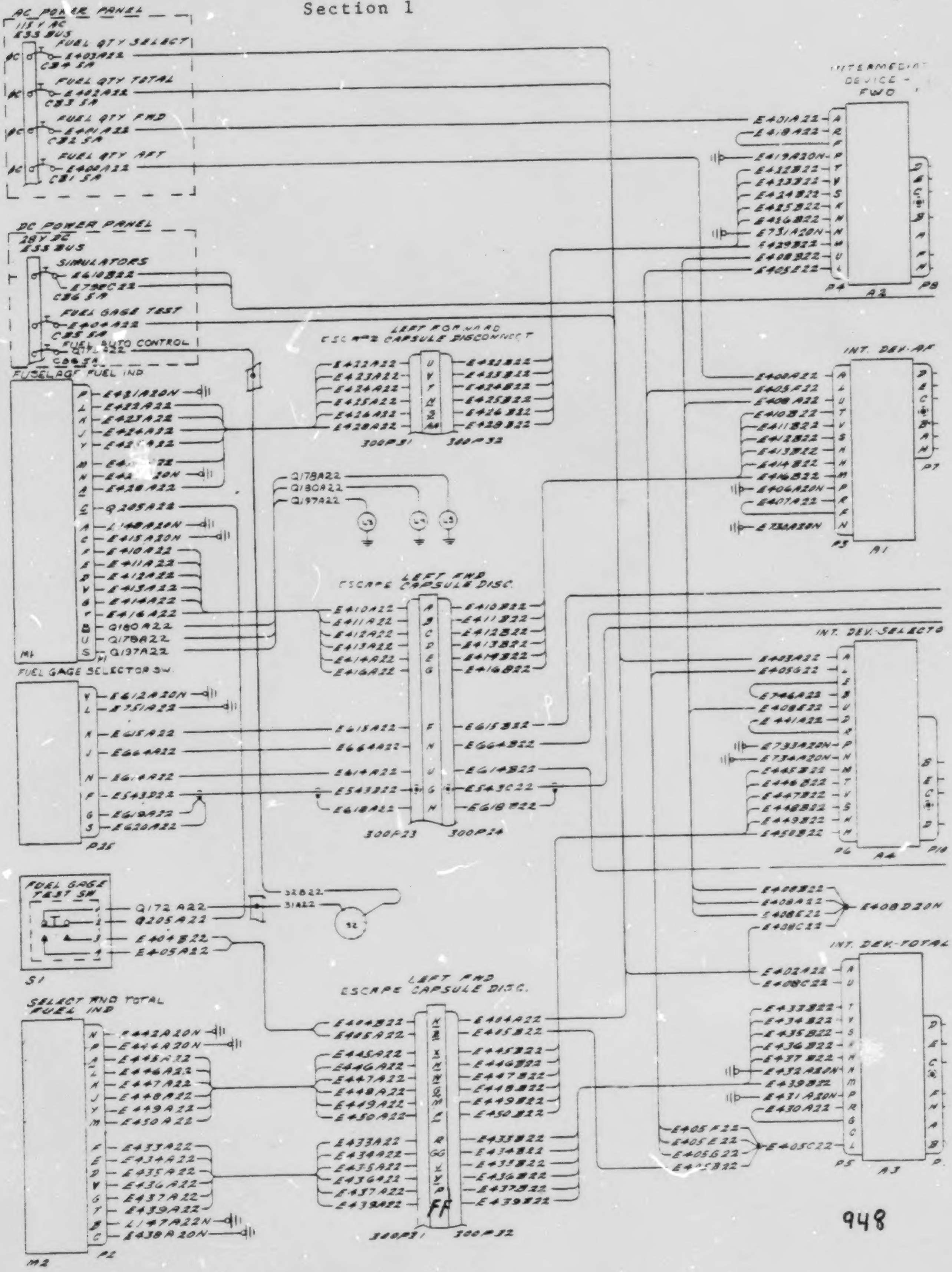
3ABR32531-HO-208
3ABR32632B-HO-307

F-111 CAPACITANCE INDICATING SYSTEM WIRING DIAGRAM

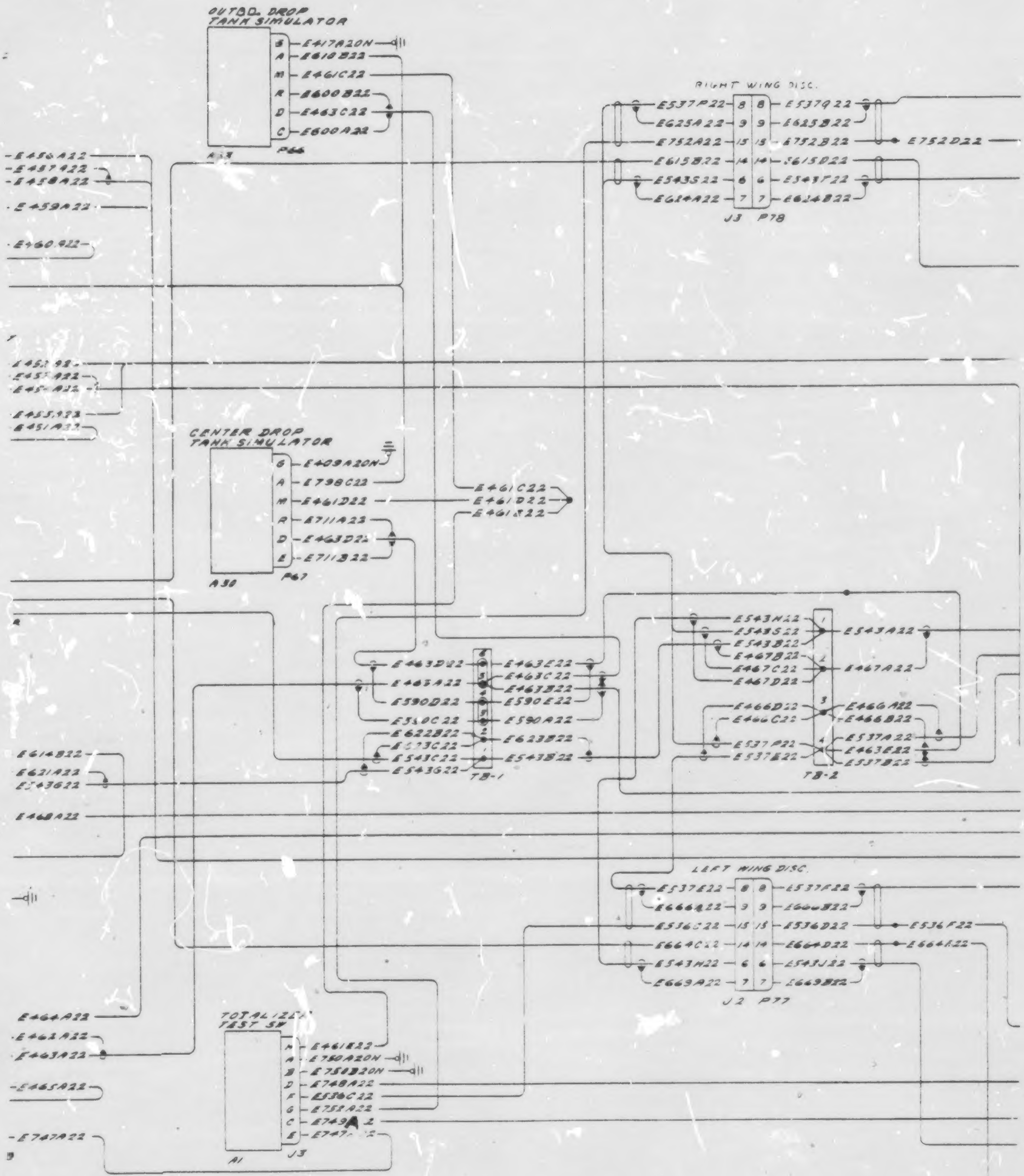
The schematic diagram in this handout supports the workbook for the F-111 Capacitance Indicating System. The diagram will be used by the students as directed by the instructor.

Supersedes 3ABR32531-HO-213, 3ABR32632B-HO-305, 11 March 1976.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 200; TTVSA - 1

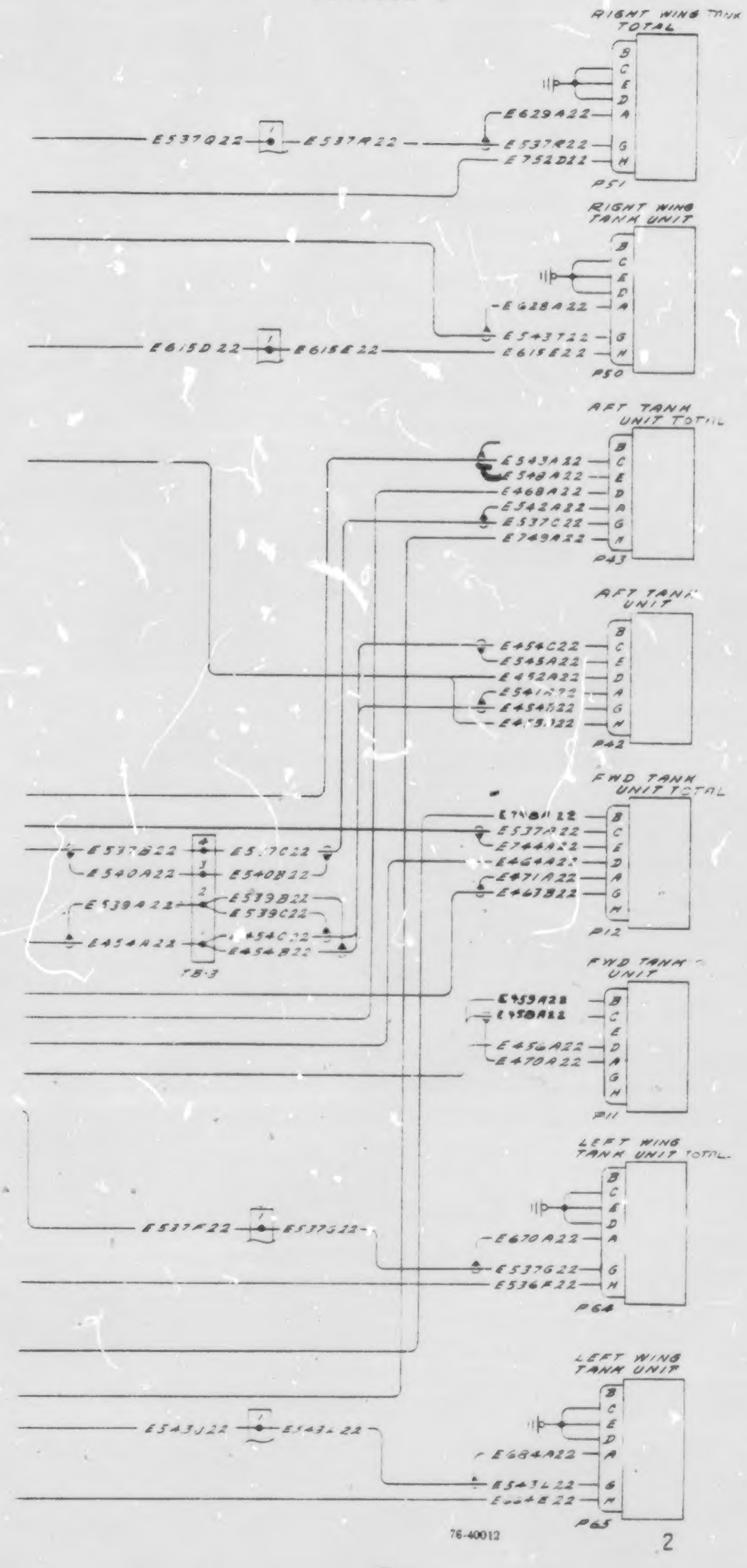
Designed for ATC Course Use. Do Not Use on the Job.


AC POWER PANEL
115 V AC
ESS BUS
FUEL QTY SELECT
E403A22
CB4 5A
FUEL QTY TOTAL
E402A22
CB3 5A
FUEL QTY FWD
E401A22
CB2 5A
FUEL QTY AFT
E400A22
CB1 5A
DC POWER PANEL
28V DC
ESS BUS
SIMULATORS
E610B22
E738C22
CB6 5A
FUEL GAGE TEST
E404A22
CB5 5A
FUEL AUTO CONTROL
Q172A22
FUSELAGE FUEL IND
M1
LEFT FORWARD ESCAPE CAPSULE DISCONNECT
300P31
300P32
INTERMEDIATE DEVICE - FWD
P4
A2
P8
INT. DEV-AFT
P5
A1
P7
LEFT AND ESCAPE CAPSULE DISC.
300P23
300P24
FUEL GAGE SELECTOR SW.
P25
INT. DEV.-SELECTOR
P6
A4
P10
FUEL GAGE TEST SW.
S1
Q172A22
Q205A22
E404B22
E405A22
32B22
31A22
E408D20N
SELECT AND TOTAL FUEL IND
M2
P2
INT. DEV.-TOTAL
P5
A3
E405C22
FF

948


OUTBD. DROP TANK SIMULATOR
S
A
M
R
D
C
E417A20N
E610B22
E461C22
E600B22
E463C22
E600A22
A33
P66
RIGHT WING DISC.
E537P22
E625A22
E752A22
E615B22
E543S22
E624A22
8
9
15
14
6
7
E537Q22
E625B22
E752B22
S615D22
E543T22
E624B22
E752D22
J3
P78
E456A22
E457A22
E458A22
E459A22
E460A22
E452A22
E457A22
E454A22
E455A22
E451A22
CENTER DROP TANK SIMULATOR
G
A
M
R
D
E
E409A20N
E798C22
E461D22
E711A22
E463D22
E711B22
A30
P67
E461C22
E461D22
E461E22
E463D22
E463A22
E590D22
E590C22
E622B22
E573C22
E543C22
E543G22
E463E22
E463C22
E467B22
E590E22
E590A22
E623B22
E543B22
6
5
4
3
2
1
TB-1
E543H22
E543S22
E543B22
E467B22
E467C22
E467D22
E466D22
E466C22
E537P22
E537E22
E543A22
E467A22
E466A22
E466B22
E537A22
E463E22
E537B22
1
2
3
4
TB-2
E614B22
E621A22
E543G22
E468A22
LEFT WING DISC.
E537E22
E666A22
E536C22
E664C22
E543H22
E669A22
8
9
15
14
6
7
E537F22
E666B22
E536D22
E664D22
E543J22
E669B22
E536F22
E664E22
J2
P77
E464A22
E462A22
E463A22
E465A22
E747A22
TOTALIZER TEST SW
M
A
B
D
F
G
C
E
E461E22
E750A20N
E750B20N
E748A22
E536C22
E752A22
E749A22
E747
A1
J3

950


RIGHT WING TANK TOTAL
E537Q22
E537R22
E629A22
E752D22
P51
RIGHT WING TANK UNIT
E628A22
E543T22
E615D22
E615E22
P50
AFT TANK UNIT TOTAL
E543A22
E548A22
E468A22
E542A22
E537C22
E749A22
P43
AFT TANK UNIT
E454C22
E545A22
E452A22
E454B22
P42
FWD TANK UNIT TOTAL
E537A22
E744A22
E464A22
E471A22
E467B22
P12
E537B22
E540A22
E540B22
E539A22
E539B22
E539C22
E454A22
E454C22
E454B22
TB-3
FWD TANK UNIT
E459A22
E458A22
E456A22
E470A22
P11
LEFT WING TANK UNIT TOTAL
E537F22
E537G22
E670A22
E536F22
P64
LEFT WING TANK UNIT
E543J22
E543L22
E684A22
P65
B
C
E
D
A
G
H

76-40012

2

PROGRAMMED TEXT
3ABR32531-PT-209

Technical Training

Avionics Instrument Systems Specialist

VERTICAL SCALE ENGINE INSTRUMENTS

30 January 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

952

FOREWORD

This programmed instructional package was prepared by the Instrument Branch at Chanute Technical Training Center. It was designed for use in Course 3ABR32531, Avionics Instrument Systems Specialist. The material contained herein has been validated using 30 students from subject course. All students achieved the objectives as stated. Average time for completion of this text was 157 minutes.

OBJECTIVES

Without references, identify facts pertaining to the purpose, operation, and/or characteristics of the typical vertical scale engine instruments:

1. Tachometers,

2. Exhaust Gas Temperature,

3. Fuel Flow,

4. Engine Pressure Ratio,

with an accuracy of at least 80% on each system.

INSTRUCTIONS

This programmed text presents information in small steps called frames. After reading the information in each frame, you are asked to make your responses on the RESPONSE SHEET. Check the accuracy of your response with the correct answers that are given after the following frame. If you make an incorrect response, study the frame again before going to the next frame. DO NOT HURRY and DO NOT RESPOND IN THIS BOOKLET!

Supersedes 3ABR32531-PT-214, 30 October 1974; 3ABR32531-PT-612, 9 December 1971; 3ABR32531-PT-614, 11 November 1971; 3ABR32531-PT-214B, 29 October 1974.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTEF - 200; TTVSA - 1

953

Frame 1

The vertical scale tachometer indicating system provides the pilot and flight engineer with indications of the speed of the engine dual compressors (N-1, N-2) for all four engines. These new tape-type instruments present the same information as the dial-type instruments previously discussed. However, the tape-type instruments have two distinct advantages over the dial-type instruments. They take up less space and are also easier to read at a glance. See figure 1.

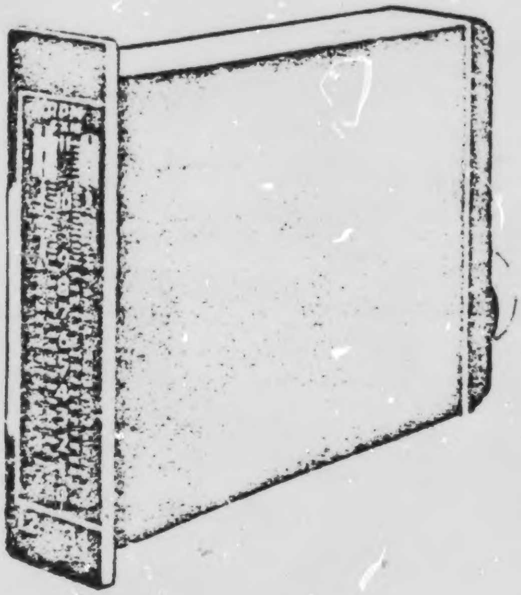


Figure 1.

Circle the letter of the correct response to the following statement.

1. The two advantages of the tape-type instrument over the dial-type instrument are that the tape-type instrument takes up

   a. more space and is easier to read.
   b. less space and is easier to read.
   c. more space and is harder to read.
   d. less space and is harder to read.

975

Frame 2

The vertical scale tachometer indicating system consists of the following units; the engine mounted, signal producing tachometer generator as shown in figure 2, the converter unit as shown in figure 3, and the indicator as shown in figure 1.

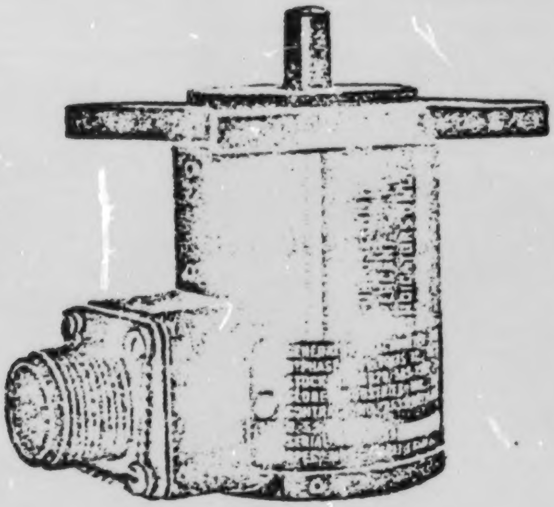


Figure 2.

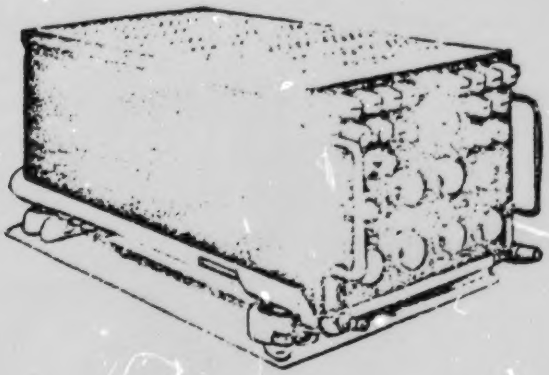


Figure 3.

NO RESPONSE REQUIRED

Answer to Frame 1: 1. b

The tachometer generator most commonly used with the vertical scale tachometer indicating system is the GEU/7A miniature generator. The generator consists of a two pole permanent magnet rotor, and a three-phase "wye" wound stator. See figure 4 for a cutaway view of the generator. Except for its size, this generator is identical to the tachometer generator you studied in the Tachometer System programmed text. The generator produces three-phase AC voltage and variable frequency signals. The amount of voltage and frequency depends on the speed of the generator rotor. As the rotor speed increases, the voltage and frequency will increase proportionately to the change in rotor speed.

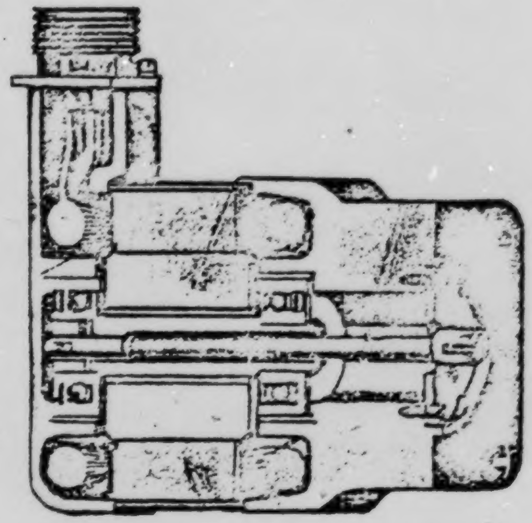


Figure 4.

Circle the letter(s) of the correct response to the following statements.

1. When the speed of the rotor increases, the generator voltage

   a. increases and frequency decreases.
   b. increases and frequency increases.
   c. decreases and frequency increases.
   d. decreases and frequency decreases.

2. The tachometer generator produces

   a. 28V DC signals.
   b. single-phase AC voltage and fixed frequency signals.
   c. three-phase AC voltage and fixed frequency signals.
   d. three-phase AC voltage and variable frequency signals.

Frame 4

TWO tachometer generators and TWO tachometer indicators are used for each engine. See figures 5 and 6 for the tachometer generators. Figure 7 on page 7 shows the TWO tachometer indicators (N-1 and N-2).

The reason for TWO tachometer generators and indicators for each engine is that the engines have dual axial compressors. The dual compressors in these engines are mechanically independent; it is possible for the compressors to turn at different speeds. Therefore, it is necessary to have an RPM indicating system for each compressor.

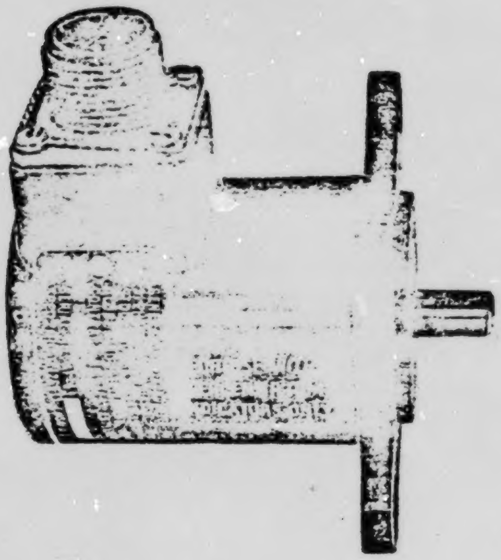


Figure 5. N-1 (Low Speed).

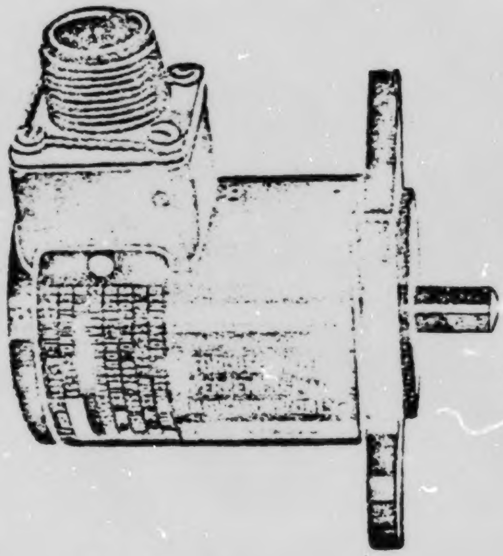


Figure 6. N-2 (High Speed).

Circle the letters of the correct response to the following statements.

1. The compressors in the engine are

   a. independent of each other.
   b. connected to each other through reduction gears.
   c. bolted to each other.

2. Two tachometer generators are needed for each engine in order to

   a. indicate the speed of each compressor.
   b. have one as a standby generator.
   c. provide a greater accuracy by sharing the load.

Answers to Frame 3: 1. b 2. d

Frame 5

See figure 7 below. The indicator labeled N-1 shows the speed of the engine's low-speed compressor in percent rpm. The indicator labeled N-2 shows the speed of the engine's high-speed compressor in percent rpm. Each indicator displays rpm of four engines on four moving tapes. The tapes are read against a stationary scale. Each numbered increment on the scale is read as percent of rpm X 10. From 0 - 9 the scale is calibrated in 5 percent increments and from 9 - 11 the scale is calibrated in 1 percent increments. These indicators are internally lighted. Notice that the word "OFF" appears at the top of each tape. This word will be in view whenever power is not applied to the system.

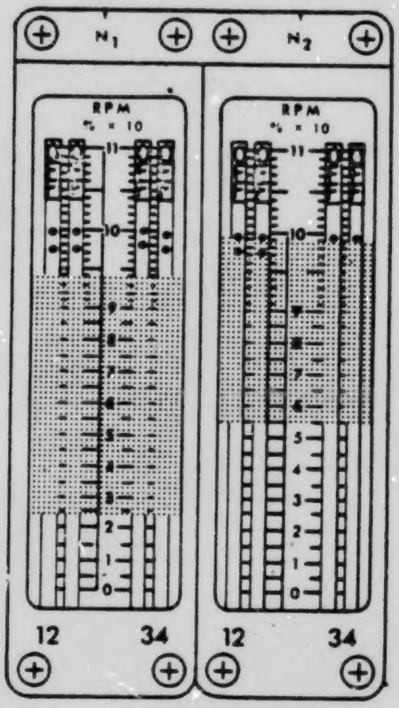


Figure 7.

Circle the letters of the correct response to the following statements.

1. The N1 indicator indicates the speed of the

   a. high speed compressor rotor.
   b. high speed turbine wheel.
   c. low speed compressor rotor.
   d. low speed turbine wheel.

Frame 5 (Continued)

2. The vertical scale tachometer indicators are calibrated to indicate

   a. percent of RPM times 10.
   b. percent of RPM times 100.
   c. increments (grad.) of 10.
   d. revolutions per minute.

Answers to Frame 4: 1. a 2. a

Frame 6

The converter unit is a shock mounted, transistorized unit containing 16 channel boards. See figure 8. The channel boards contain the conversion circuitry and amplifiers necessary to operate the vertical scale indicating systems. Since we are studying the vertical scale tachometer system, we are going to study the rpm channel boards shown on the upper left of figure 8. There is one channel board for each tachometer indicator system. We will cover the other channel boards in other lessons.

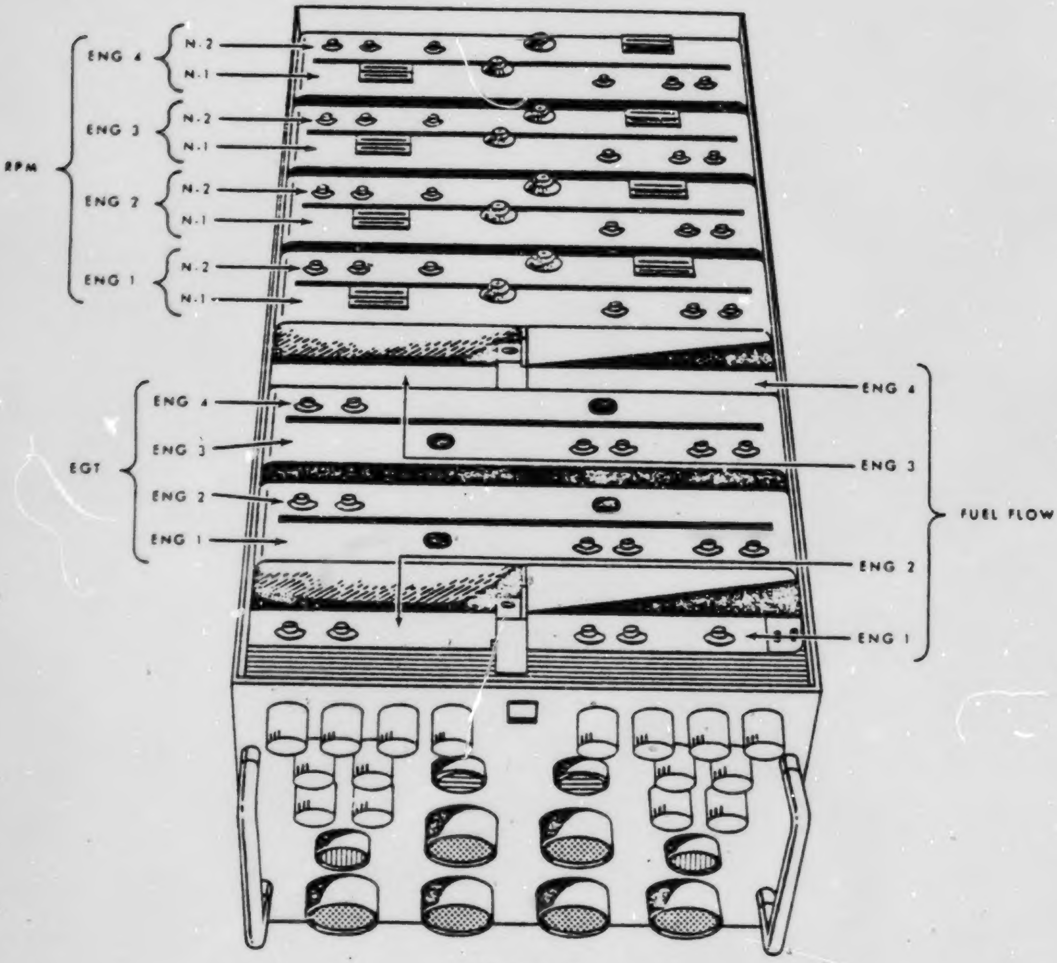

RPM
ENG 4
N-2
N-1
ENG 3
N-2
N-1
ENG 2
N-2
N-1
ENG 1
N-2
N-1
EGT
ENG 4
ENG 3
ENG 2
ENG 1
FUEL FLOW
ENG 4
ENG 3
ENG 2
ENG 1

Figure 8.

Circle the letter of the correct response to the following statement.

1. The vertical scale tachometer indicating system contains

   a. 4 channel boards.
   b. 8 channel boards
   c. 12 channel boards.
   d. 16 channel boards.

Answers to Frame 5: 1. c 2. a

Frame 7

Sixteen fuses and ten connectors are located on the front of the converter. See figure 9. These fuses are numbered F-1 through F-16. There is one fuse for the protection of each of the 16 channels of the converter unit. The fuse number and the circuit that it protects is listed on the top of the converter unit. The connectors are numbered J-1 through J-10 and provide a means of connecting the signal-sensing components and the vertical scale indicators to the converter unit.

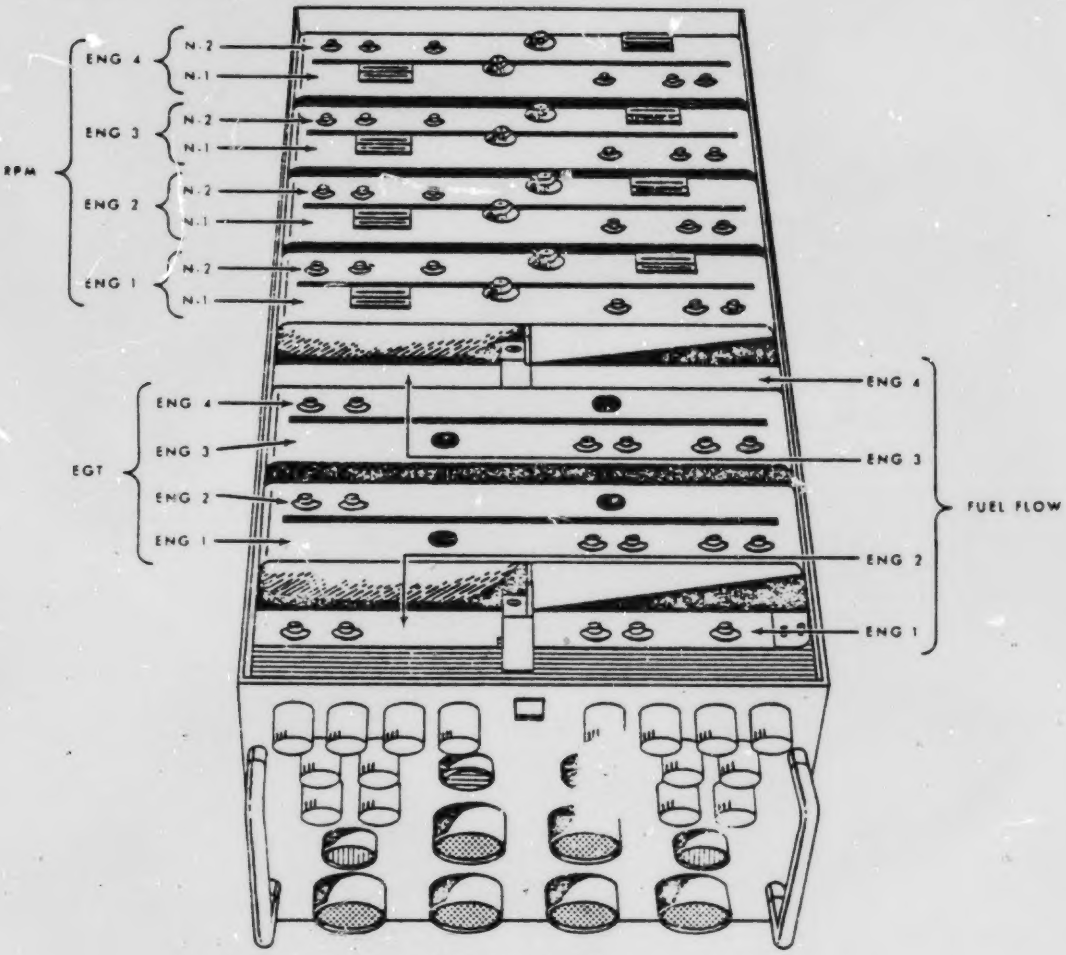

ENG 4
N-2
N-1
ENG 3
N-2
N-1
RPM
ENG 2
N-2
N-1
ENG 1
N-2
N-1
ENG 4
EGT
ENG 3
ENG 2
ENG 1
ENG 4
ENG 3
FUEL FLOW
ENG 2
ENG 1

Figure 9.

Circle the letter of the correct answer.

1. The engine rpm channel circuits are protected by

   a. 2 fuses.
   b. 4 fuses.
   c. 8 fuses.
   d. 16 fuses.

Answer to Frame 6: 1. b

The rpm channels receive variable N-1 or N-2 tachometer generator signals. Each channel contains the circuits necessary to convert the output of the generator to a DC signal. The amplitude of this DC signal depends on the frequency output of the generator. The DC signal is then modulated to a 400-Hz AC signal, amplified, and supplied to the rpm indicator servomotors. Eight identical rpm channel boards are used in the converter unit. The channel boards may be interchanged with each other. The position of the channel boards are shown in figure 9 of the preceding frame.

Circle the letters of the correct answers.

1. The tachometer generator signal is sent to the

   a. modulator.
   b. rpm channel board.
   c. vertical tape tachometer indicator.

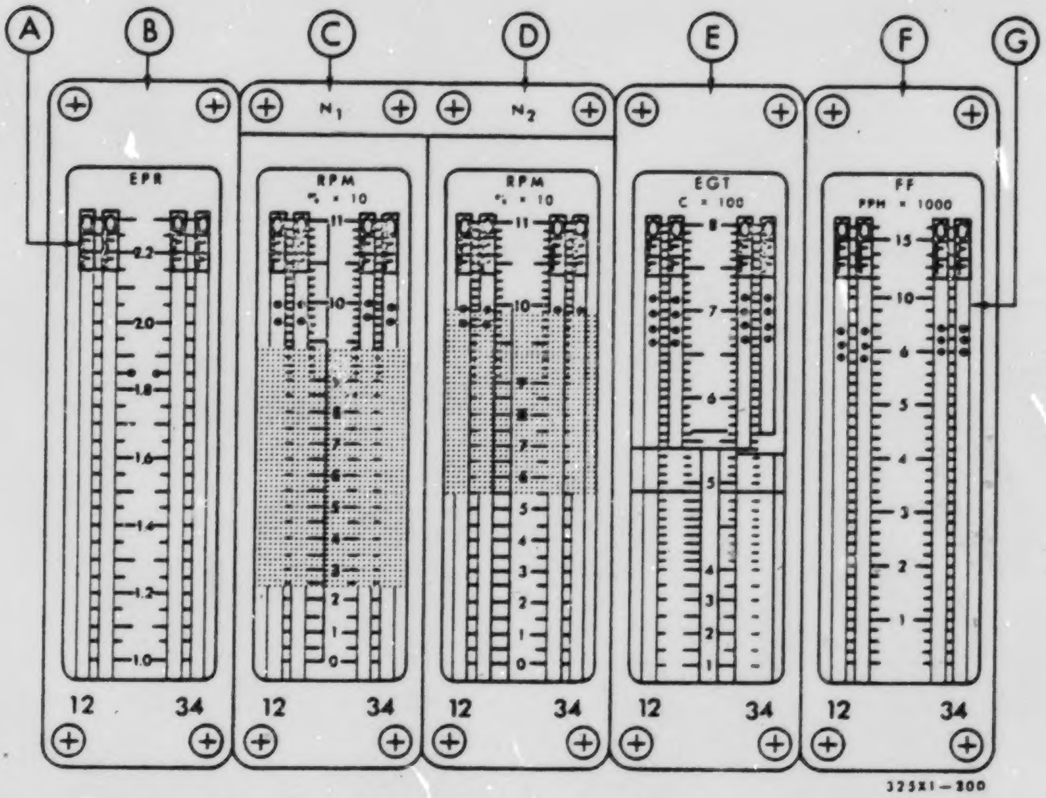
2. The purpose of the converter is to

   a. convert, modulate, and amplify the generator signal.
   b. amplify the variable three-phase signal.
   c. amplify the 115V AC signal.

Answer to Frame 7: 1. c

Frame 9

A typical arrangement of the vertical scale engine instrument indicators is shown in figure 10. Notice that the rpm indications (C + D) for all eight engine compressors are shown on the two rpm indicators. The vertical scale indicators are internally lighted. Two identical sets of the indicators are used in the vertical scale engine instrument system. One set is mounted on the pilot's engine instrument panel and the other set is mounted on the flight engineer's panel. The word OFF (A) appears at the top of the indicators when power is not applied to the system.


A
B
C
D
E
F
G
N1
N2
EPR
RPM
% × 10
RPM
% × 10
EGT
C × 100
FF
PPH × 1000
2.2
2.0
1.8
1.6
1.4
1.2
1.0
11
10
9
8
7
6
5
4
3
2
1
0
8
7
6
5
4
3
2
1
15
10
6
5
4
3
2
1
12
34
325X1-300

A. POWER OFF INDICATORS
B. ENGINE PRESSURE RATIO INDICATOR
C. TACHOMETER (RPM) INDICATOR (N_1)
D. TACHOMETER (RPM) INDICATOR (N_2)
E. EXHAUST GAS TEMPERATURE INDICATOR
F. FUEL FLOW INDICATOR
G. MOVABLE TAPES

Figure 10.

Refer to figure 10 (page 12) to answer the following questions. Circle the letters of the correct answers.

1. The rpm vertical scale tachometer indicators are calibrated to indicate
   - a. percent of rpm times 10.
   - b. percent of rpm times 100.
   - c. increments of ten.
   - d. revolutions per minute.
2. The vertical scale tachometer indicators are lighted by
   - a. external lighting.
   - b. indirect lighting.
   - c. internal lighting.
   - d. fluorescent lighting.

Answers to Frame 8: 1. b 2. a

Frame 10

Two rpm indicators are located on each panel. See figure 11. The rpm indicator, labeled N-1, shows the speed of the engine's low-speed compressor in percent of rpm. The rpm indicator labeled N-2 shows the speed of the engine's high speed compressor in percent of rpm. Each indicator displays the rpm of four engines on four moving tapes. The tapes are read against a stationary scale. Each numbered increment on the scale is read as percent of rpm X 10. From 0-9 the scale is calibrated in 5 percent increments and from 9 to 11 the scale is calibrated in 1 percent increments.

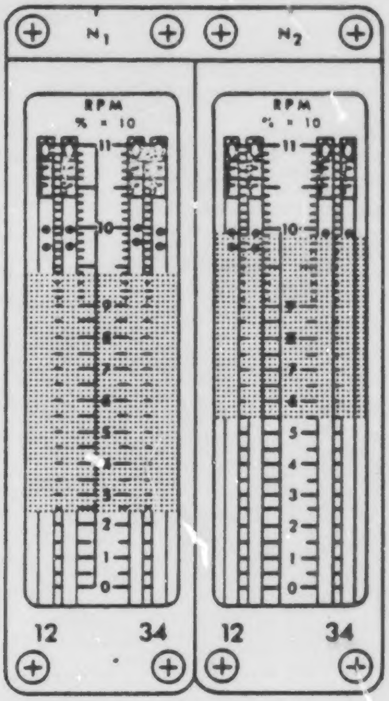


Figure 11.

Circle the letters of the correct answers.

1. The type N-1 tachometer indicator indicates the speed of the
   - a. high speed compressor rotor in percent of rpm.
   - b. aircraft in percent of miles per hour.
   - c. low speed compressor rotor in percent of rpm.
   - d. jet engine turbine wheel in percent of rpm.

2. The type N-2 tachometer indicator indicates the speed of the
   - a. aircraft in percent of knots.
   - b. high speed compressor rotor in percent of rpm.
   - c. low speed compressor rotor in percent of rpm.
   - d. jet engine turbine wheel in percent of rpm.

Answers to Frame 9: 1. a 2. c

Refer to the vertical scale tachometer indicating system diagram (figure 13) at the end of section A (page 27), and use it with the SEVEN following frames.

Notice that the rpm indicators contain a servomotor and gear train for each indicator tape. A variable potentiometer (R1) driven by the gear train is also incorporated for each tape. The variable potentiometer provides a rebalance voltage back to the rpm channel board. This is called potentiometer feedback. Notice the dotted lines from the servomotor. These lines represent the gear train. The following frames will explain the operation of the vertical scale RPM indicating system.

Refer to the diagram and circle the letter of the correct response to the following statement.

1. The servomotor of one indicator will drive

   a. one variable potentiometer and one tape.
   b. two variable potentiometers and two tapes.
   c. one variable potentiometer and two tapes.

Answers to Frame 10: 1. c 2. b

Frame 12

When the circuit breaker is closed, 115V AC 400-Hz single-phase power is applied to the power supply of the rpm channel board and to the fixed phase of the servomotors in the pilot's and flight engineer's indicators. The channel board power supply furnishes the regulated DC voltages for the amplifiers, the rebalance potentiometer (R1) in the indicator, and an AC reference voltage to the modulator circuits.

Circle the letter of the correct response to the following statement.

1. The voltage requirement for the operation of the rpm vertical scale instrument is

   a. 115V AC 60-Hz single-phase.
   b. 115V AC 400-Hz single-phase.
   c. 115V AC 60-Hz three-phase.

Answer to Frame 11: 1. a

Notice in the diagram that the DC output from the converter (frequency to voltage) is supplied to the pilot's and flight engineer's modulator circuits. The magnitude of the voltage output depends on the input frequency from the tachometer generator. From this point on, the pilot's and flight engineer's circuits are identical and independent of each other. Therefore, we will discuss ONLY the pilot's circuit.

Circle the letter of the correct response to the following statement.

1. The magnitude of the DC voltage received by the modulator depends on the
    - a. frequency output of the tachometer generator.
    - b. amount of voltage supplied to the AC bus bar.
    - c. speed of the servomotor.

Answer to Frame 12: 1. b

968

Frame 14

When power is applied to the system and the engines are not running, a small DC output from the converter is supplied to the modulator circuits. The modulator circuit changes the small DC signal to a small 400 Hz AC signal. The small AC signal is fed to an amplifier where the signal is boosted in strength. From the amplifier the signal is fed to an amplifier clipper. Inside the clipper, a portion of the signal that is not needed is clipped. The clipped signal is then supplied to a push-pull amplifier circuit. Here the signal is amplified again and is supplied to the control phase of the servomotor in the indicator. The servomotor starts running when it receives the amplified signal.

Refer to the vertical scale tachometer indicating system diagram and circle the letter of the correct response to the following statement.

1. When the AC power is applied to the aircraft system, a signal from the converter drives

   a. one servomotor and one N-1 tape.
   b. one servomotor and two N-1 tapes.
   c. two servomotors and two N-1 tapes.
   d. two servomotors and one N-1 tape.

990

Answer to Frame 13: 1. a

As the servomotor runs, it drives a gear train that positions the tape and the wiper of the potentiometer R-1. The servomotor continues to run until the DC rebalance or feedback signal felt on the wiper of the potentiometer R-1 is of sufficient strength to cancel the modulator DC input from the converter. At this time, the servomotor stops. The indicator tape has now moved up just far enough to remove the word "OFF" from view. The indicator tape now appears blank except for the calibrated scale. See vertical scale tachometer indicating system diagram.

Refer to the diagram and circle the letter of the correct response to the following statement.

1. The servomotor stops when the modulator receives a sufficient DC signal from the

   a. converter.
   b. power supply.
   c. R-1 wiper.
   d. DC bus.

Answer to Frame 14: 1. c

Frame 16

The tape is mechanically positioned by the gear train and two tape drums. The tape threading route and the tape drums are shown in figure 12. When the gear train is turned by the servomotor, the tape drum rotates in the direction shown by the arrow on its side. The small tape take-up drum is turned at the same time in the direction shown by the arrow on its side. Refer to figure 12 and trace the tape from the tape drum to the take-up drum. When power is applied to the system, the tape moves and the word OFF is removed from view on the indicator. When power is removed from the system for any reason, a spiral spring inside the tape drum returns the OFF portion of the tape into view through spring tension.

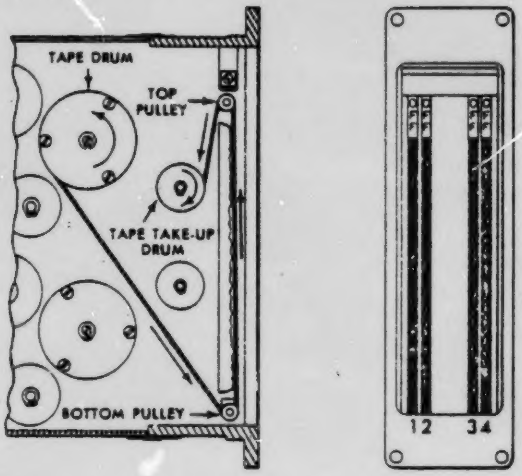


Figure 12.

Circle the letter of the correct response to the following statement.

1. The purpose of the spiral spring is to

   a. aid the servomotor in drawing the tape upscale.
   b. aid the servomotor in driving the tape downscale.
   c. return the tape to OFF when power is removed.

Answer to Frame 15: 1. c

With power applied and the word OFF out of view, the system works as follows when the engine is running. As the engine is started, the rotor of the tachometer generator starts to turn, this produces a three-phase AC signal of variable frequency, that is proportional to the rotor speed. This variable signal is fed into a push-pull amplifier. The push-pull amplifier boosts the generator output to a usable signal for the converter.

Circle the letter of the correct response to the following statements.

1. The output of the tachometer generator is a variable frequency

   a. square-wave DC signal.
   b. single-phase AC signal.
   c. two-phase AC signal.
   d. three-phase AC signal.

2. The push-pull amplifier is used to amplify the

   a. tachometer generator signals.
   b. signals from R-1 potentiometer.
   c. 115V AC signals sent to the servomotor.

Answer to Frame 16: 1. c

Frame 18

The converter changes the AC signal from the push-pull amplifier to a DC signal. The magnitude of the DC signal increases as the frequency of the generator's AC output increases. The DC signal is then fed to the pilot's and flight engineer's modulator circuits. The modulator changes the DC signal to a 400 Hz AC signal of the proper phasing to cause the servomotor to drive up scale. The phasing of the signal is referenced to line voltage.

Circle the letter of the correct response to the following statement.

1. The converter is used to change the

    a. DC from the R-1 potentiometer to AC.
    b. AC from the push-pull amplifier to DC.
    c. AC from the amplifier clipper to DC.
    d. AC from the power amplifier to DC.

Answers to Frame 17: 1. d 2. a

From the modulator, the 400 Hz AC signal is fed to an amplifier where the signal is boosted in strength. This amplified signal is then fed into an amplifier clipper where a portion of the signal that is not needed is clipped. The clipped signal is sent to a power amplifier where it is again increased in strength. This amplified signal is then sent to the control phase of a servomotor causing it to run.

Circle the letter of the correct response to the following statement.

1. The amplified signal from the power amplifier is sent to the
   a. fixed phase of the servomotor.
   b. control phase of the servomotor.
   c. R-1 potentiometer.

Answer to Frame 18: 1. b

974

Frame 20

As the servomotor drives, the tape is positioned to show an increase in rpm. At the same time, the wiper arm of the potentiometer R-1 is moved. The motor continues to drive until the DC voltage felt on the wiper of R-1 is of sufficient strength to cancel the DC signal sent from the converter to the modulator.

Circle the letter of the correct response to the following statement.

1. The purpose of the R-1 potentiometer is to cancel the

   a. converter DC signal.
   b. modulator AC signal.
   c. amplifier clipper signal.
   d. power amplifier signal.

996

Answer to Frame 19: 1. b

When the generator frequency increases, the DC output from the converter increases. In this case, the DC output voltage from the converter is now greater than the feedback voltage from potentiometer R-1. The modulator now produces an AC signal that is of such phasing with the line voltage, that it will cause the servomotor to run and drive the tape upscale.

Circle the letter of the correct response to the following statement.

1. As the generator frequency increases, the DC output of the

   a. power supply increases.
   b. power supply decreases.
   c. converter increases.
   d. modulator decreases.

Answer to Frame 20: 1. a

976

Frame 22

When the generator frequency decreases, the DC output from the converter decreases. In this case, the DC output from the converter is now less than the feedback voltage from potentiometer R-1. The modulator now produces an AC signal that is of such phasing with the line voltage, that it will cause the servomotor to run and drive the tape down scale.

Circle the letter of the correct response to the following statement.

1. As the generator frequency decreases, the DC output of the

   a. R-1 potentiometer is greater than the output of the converter.
   b. R-1 potentiometer is less than the output from the converter.
   c. modulator decreases.

Answer to Frame 21: 1. c

Answer to Frame 22: 1. a

Take appraisal on section A.

27

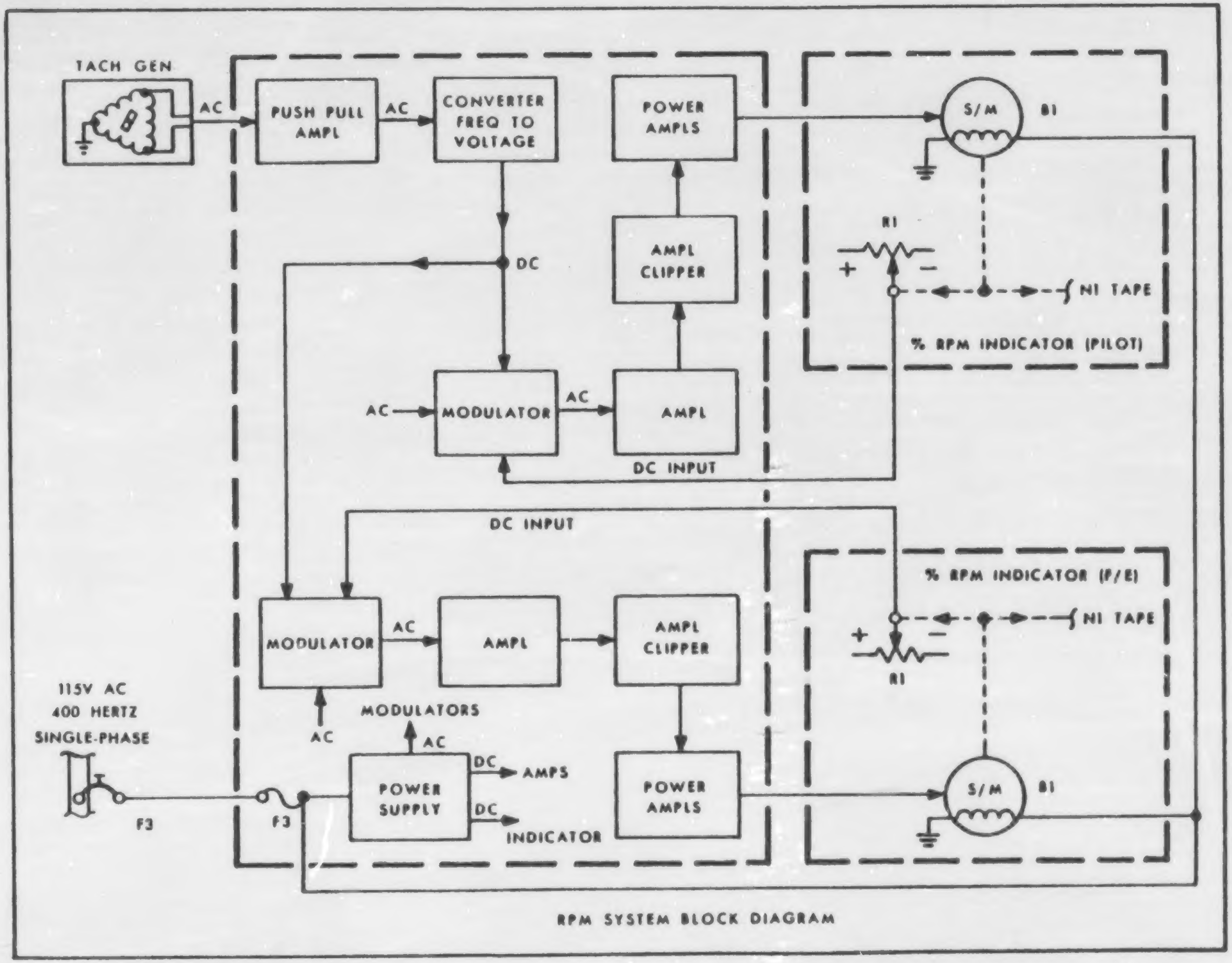

TACH GEN
AC
PUSH PULL AMPL
AC
CONVERTER FREQ TO VOLTAGE
POWER AMPLS
S/M
B1
R1
+
−
NI TAPE
% RPM INDICATOR (PILOT)
DC
AMPL CLIPPER
AC
MODULATOR
AC
AMPL
DC INPUT
DC INPUT
% RPM INDICATOR (F/E)
NI TAPE
+
−
R1
MODULATOR
AC
AMPL
AMPL CLIPPER
115V AC
400 HERTZ
SINGLE-PHASE
AC
MODULATORS
AC
DC
AMPS
POWER SUPPLY
DC
INDICATOR
POWER AMPLS
S/M
B1
F3
F3
RPM SYSTEM BLOCK DIAGRAM

Figure 13. Vertical Scale Tachometer Indicating System.

Frame 23

979

999

1000

Section B

Frame 1

The vertical scale exhaust gas temperature system provides the pilot and flight engineer with the indications of exhaust gas temperature in degrees Celsius on four vertical tapes. The system consists of the engine-mounted signal-producing components, the converter units, and the indicators. Figure 1 shows the thermocouple (signal producing component), figure 2 shows the converter and figure 3 shows the indicator.

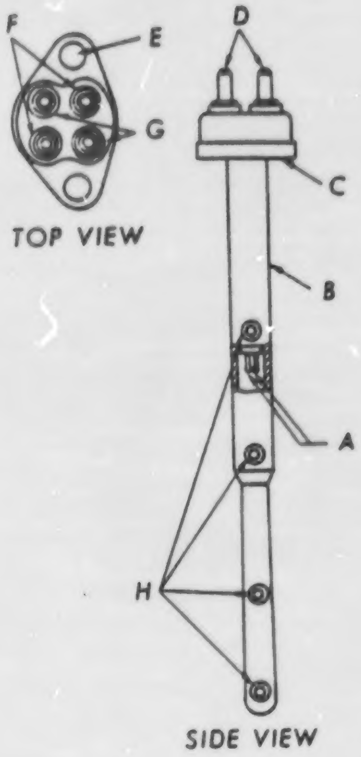


Figure 1.

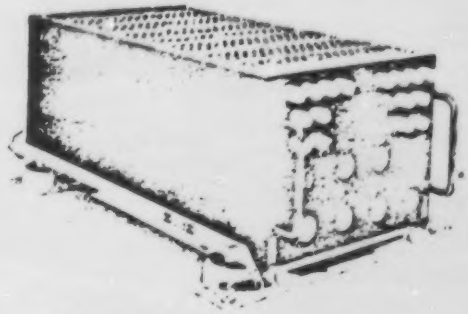


Figure 2.

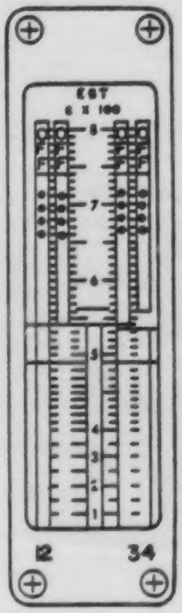


Figure 3.

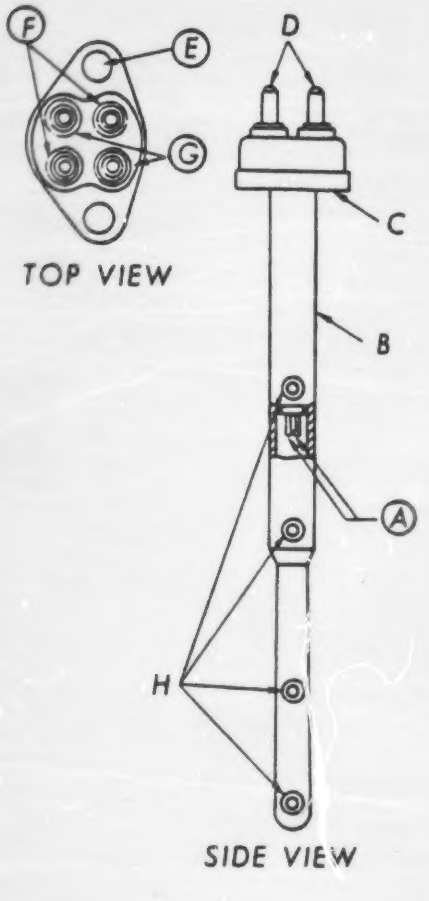
Circle the letter of the correct response to the following statement.

1. The vertical scale exhaust gas temperature indicating system indicates the exhaust gas temperature in

   a. DC millivolts.
   b. degrees Celsius.
   c. AC millivolts.
   d. degrees Fahrenheit.

Frame 2

The EGT thermocouple probes are similar in appearance to the thermocouple probes you studied earlier in this block. Each of the probes used with this particular system contains two chromel-alumel thermocouples. See figure 4. Notice that the two thermocouples are mounted inside the probe housing. See A of figure 4. The probe is inserted into the exhaust section of the engine and held securely by two bolts extending through the mounting flange (E of top view). The thermocouples are connected to the thermocouple leads by the terminal posts (F and G) on top of the probe.



A. Thermocouples
B. Probe
C. Mounting Flange
D. Terminal Post
E. Mounting Holes
F. Alumel Connecting Post
G. Chromel Connecting Post
H. Exhaust Gas Inlet-Outlet Ports

Figure 4.

Circle the letter of the correct response to the following statement.

1. The two thermocouples are made of

   a. iron-constantan and chromel-alumel.
   b. copper-iron and alumel-constantan.
   c. iron-alumel and chromel-constantan.
   d. chromel-alumel.

Answer to Frame 1: 1. b

Frame 3

The small ports, items H in figure 4, in the probe allow the hot exhaust gases to reach the thermocouples. The protective probe around the thermocouples aids in reducing erosion of the thermocouples. This erosion is caused by the extremely high exhaust gas temperatures and carbon particles discharged from the engine.

Circle the letter of the correct response to the following statement.

1. The purpose of the protective probe is to protect the thermocouple from

   a. moisture.
   b. overheating.
   c. erosion.
   d. vibration.

Answer to Frame 2: 1. d

Frame 4

The exhaust gas temperature is sensed by six thermocouple probes spaced around the engine exhaust discharge passage. Each thermocouple develops a DC millivolt signal proportional to the temperature of the exhaust gas at its location. The six thermocouples, as shown in figure 5, are connected in parallel. An average voltage of the six individual DC signals is provided as an input to the converter's EGT channel board.

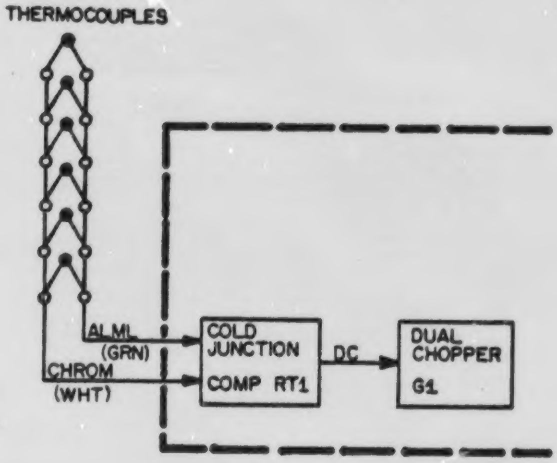


Figure 5.

Circle the letter of the correct response to the following statements.

1. The six thermocouples that sense the temperature of the EGT indicating system develops an average DC signal, because they are connected in

   a. series.
   b. parallel.
   c. series-parallel.

2. The thermocouple sends

   a. an AC millivolt signal to the converter's channel boards.
   b. a DC millivolt signal to the converter's channel boards.
   c. an AC voltage to the converter's channel boards.

Answer to Frame 3: 1. c

982

Frame 5

You were told in frame 2 that each thermocouple probe contained two thermocouples. The reason for this, is that one thermocouple is used in the indicating system, and the other thermocouple is wired to the spread thermocouple test receptacle. These dual-type thermocouple probes are shown in figure 6. The spread thermocouples are used separately from the aircraft's indicating system. They are used to check the engine for proper combustion (engine trim). This includes tests that are required with the engine removed from the aircraft.

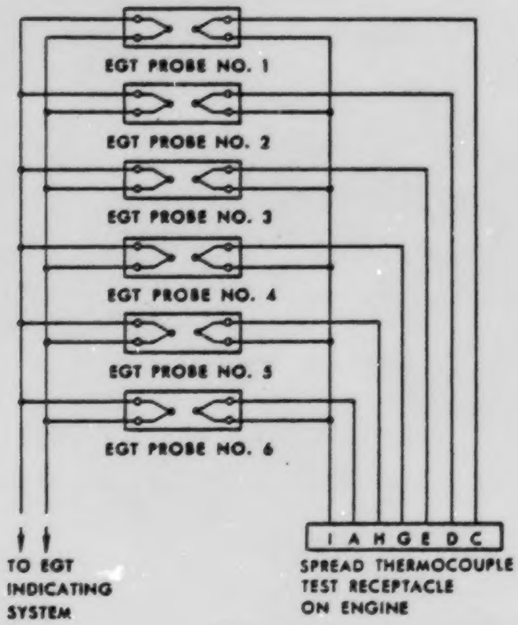

EGT PROBE NO. 1
EGT PROBE NO. 2
EGT PROBE NO. 3
EGT PROBE NO. 4
EGT PROBE NO. 5
EGT PROBE NO. 6
I A H G E D C
TO EGT INDICATING SYSTEM
SPREAD THERMOCOUPLE TEST RECEPTACLE ON ENGINE

Figure 6.

Refer to figure 6 and circle the letter of the correct response to the following statement.

1. The six spread thermocouples are used for

   a. the pilot's indicating system.
   b. the engineer's indicating system.
   c. checking the engine for proper combustion.

1005

Answers to Frame 4: 1. b 2. b

Frame 6

A similar converter unit that was described in section A is used with the vertical scale exhaust gas temperature indicating system. Four channel boards are used, one for each engine to process the DC millivolt input signals into 400 Hz AC signals to operate the vertical scale tapes.

Circle the letter of the correct response to the following statement.

1. The converter channel board converts a DC millivolt signal into a

   a. 400 Hz AC signal.
   b. square wave DC signal.
   c. 60V AC, 60 Hz AC signal.
   d. 110V AC, 60 Hz AC signal.

Answer to Frame 5: 1. c

984

Frame 7

Except for the calibrated scale, the EGT indicators are constructed identical to the RPM indicators. The EGT scale has a range from 100 degrees to 800 degrees C. From 100 degrees to 400 degrees C the scale is calibrated in 50 degrees increments. From 400 degrees to 800 degrees C the scale is calibrated in 10 degree increments. Each numbered increment on the scale is read in degrees Celsius X 100.

Circle the letter of the correct response to the following statement.

1. The indicator that is cal!trated in degrees Celsius is the

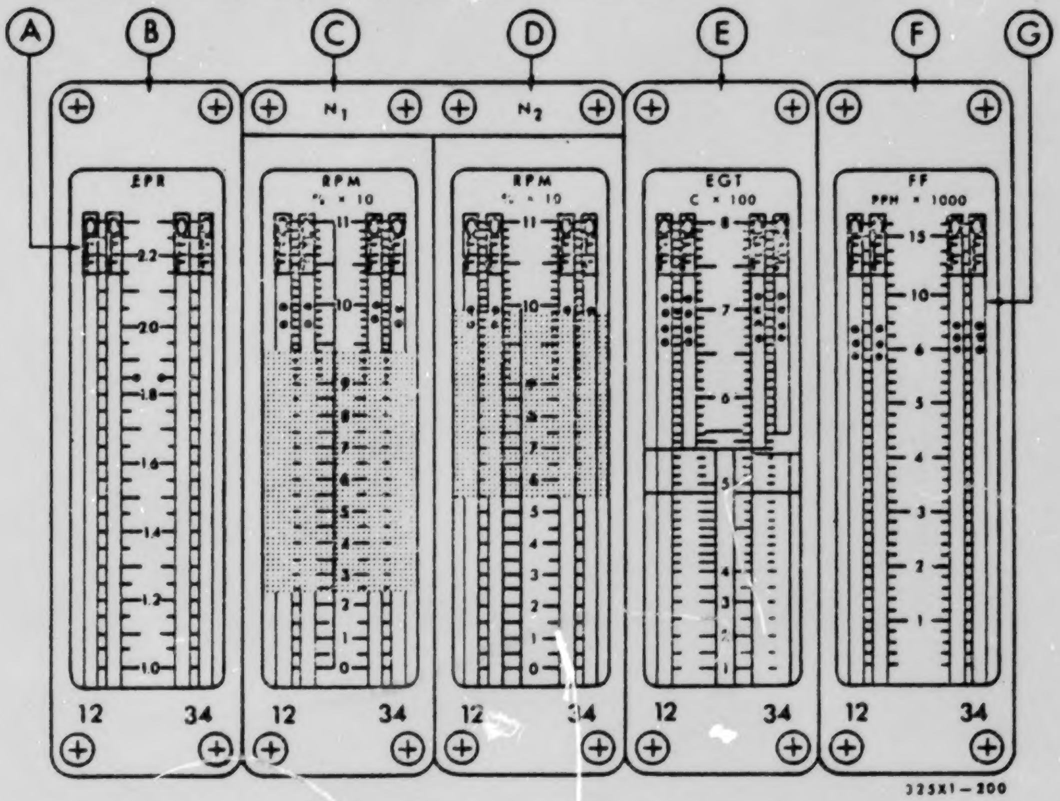
   a. EPR indicator.
   b. RPM indicator.
   c. EGT indicator.
   d. fuel flow indicator.

Answer to Frame 6: 1. a

1007

Frame 8

Notice in figure 7 that the OFF flag shows at the top of the indicator (A) before power is applied to the system. This is because the spiral spring in the tape drum has rotated the gear train backwards and causes the word OFF to appear. At the same time, the wiper of potentiometer R1 in the indicator has moved to a position lower than normal. Movable tapes (G) show the indications.



A. POWER OFF INDICATORS
B. ENGINE PRESSURE RATIO INDICATOR
C. TACHOMETER (RPM) INDICATOR (N_1)
D. TACHOMETER (RPM) INDICATOR (N_2)
E. EXHAUST GAS TEMPERATURE INDICATOR
F. FUEL FLOW INDICATOR
G. MOVABLE TAPES

Figure 7.

Refer to figure 7 and circle the letter of the correct response to the following statement.

1. The word OFF appears on the indicator when power is removed due to

   a. spring tension on the tape drum.
   b. the motor driving the tape down.
   c. the motor driving the tape up.

Answer to Frame 7: 1. c

Frame 9

Refer to the vertical scale exhaust gas temperature system (EGT) diagram, figure 8, at the end of section B (page 43) and use it with frames 9, 10, and 11.

Notice the 115V AC, 400-Hz single-phase circuit breaker. When the circuit breaker is closed (assume that power is applied to the aircraft), AC voltage is applied to the power supply of the EGT channel. The power supply furnishes the DC voltages to the amplifiers and the DC reference voltage to potentiometers R1 in the pilot's and flight engineer's indicators. The voltage is also supplied to the indicators for servomotor excitation.

Circle the letter of the correct response to the following statements.

1. The voltage requirement for vertical scale servomotor excitation is

   a. a square wave DC signal.
   b. 115V AC, 60-Hz single-phase.
   c. 115V AC, 400-Hz, single-phase.
   d. 115V AC, 400-Hz, three-phase.

2. The power supply provides DC voltage for the dual chopper, follow-up potentiometer and the

   a. amplifiers.
   b. thermocouples.
   c. fixed phase of the servomotor.

Answer to Frame 8: 1. a

Notice in figure 8 that the thermocouple circuit is connected to the cold junction compensator on the EGT channel board. The cold junction compensator provides a constant millivolt reference voltage regardless of temperature changes. When power is applied to the system a DC millivolt signal is produced by the cold junction compensator. This signal is larger in magnitude than the DC feedback signal from potentiometer R1, in the indicator.

Circle the letter of the correct response to the following statements.

1. The cold junction compensator sends
   a. an AC signal to the dual chopper.
   b. a square wave signal to the dual chopper.
   c. an AC millivolt signal to the dual chopper.
   d. a DC millivolt signal to the dual chopper.

2. When power is applied to the system, the potentiometer DC feedback signal is
   a. smaller than the signal produced by the cold junction compensator.
   b. higher than the signal produced by the cold junction compensator.
   c. the same strength as the signal produced by the cold junction compensator.

3. The cold junction compensator is located
   a. in the thermocouple.
   b. in the EGT indicator.
   c. in the thermocouple lead.
   d. on the EGT channel board.

Answers to Frame 9: 1. c 2. a

Frame 11

Refer to figure 8 again. The DC millivolt signal supplied by the cold junction compensator is sent to the dual chopper. The dual chopper contains TWO independent choppers; ONE for the pilot's indicating system and ONE for the flight engineer's indicating system. From this point on, both circuits are the same. Therefore, we will cover only the pilot's system.

In the chopper circuit, the DC millivolt signal from the cold junction compensator is changed to a 400-Hz AC signal. The AC signal is supplied to an amplifier where it is boosted in strength. The boosted signal is fed to a clipper circuit (Q1, 3, & 5) where a portion of a signal that is not needed is clipped. The clipped signal is then amplified by the power amplifier. The output of the power amplifier is fed to the control phase of the servomotor in the indicator.

Circle the letter of the correct response to the following statement.

1. The amplified 400-Hz AC signal is applied to the

   a. fixed phase of the servomotor.
   b. control phase of the servomotor.
   c. follow-up potentiometer.

Answers to Frame 10: 1. d 2. a 3. d

As the servomotor drives, the tape is repositioned and the wiper of potentiometer R1 is moved. The servomotor continues to drive until the DC voltage on the wiper of R1 is of the same value as the DC signal supplied to the chopper. At this time, the servomotor stops and the word OFF is removed from view. The indicator now appears blank except for the calibrated scale. This system uses a servoloop where the potentiometer provides the feedback signal for nulling the DC signal supplied to the chopper.

Circle the latter of the correct response to the following statement.

1. The EGT vertical scale system uses a servoloop that is nulled by a

   a. synchro feedback signal.
   b. wheatstone bridge feedback signal.
   c. potentiometer feedback signal.

Answer to Frame 11: 1. b

Frame 13

When the engine is started and heat is applied to the thermocouples, a DC millivolt signal is produced in the thermocouple circuit. The DC millivolt signal is applied to the cold junction compensator. This increase in voltage is applied to the dual chopper. Remember the DC signal from the cold junction compensator is now stronger than the feedback signal from the potentiometer R1 in the indicator.

Refer to the EGT diagram and circle the letters of the correct response to the following statements.

1. As heat is applied to the thermocouples, they produce

   a. a square wave signal.
   b. an AC signal.
   c. a DC millivolt signal.
   d. an AC millivolt signal.

2. The thermocouple signal is sent to the

   a. cold junction compensator.
   b. power supply.
   c. followup potentiometer.

Answer to Frame 12: 1. c

The DC millivolt signal from the cold junction compensator is changed to a 400-Hz AC signal in the dual chopper. This AC signal is supplied to an amplifier where it is boosted in strength. The boosted signal is fed to a clipper circuit where a portion of the signal that is not needed is clipped. This clipped signal is sent to a power amplifier. The output of the power amplifier is fed to the control phase of the servomotor causing the motor to run. This repositions the tape and the wiper of R1. When the TWO DC signals at the chopper are equal, but opposite in polarities, the motor stops and the indicator now indicates the exhaust gas temperature in degrees Celsius.

Refer to figure 8 and circle the letters of the correct response to the following statements.

1. The DC millivolt signal from the cold junction compensator is sent to the

   a. amplifier.
   b. dual chopper.
   c. power amplifier.
   d. clipper

2. The servomotor stops running when the DC signal of the potentiometer is

   a. higher than the DC signal of the chopper.
   b. lower than the DC signal of the chopper.
   c. the same strength, but opposite in polarity to the DC signal of the chopper.
   d. greater strength, but opposite in polarity to the DC signal of the chopper.

Answers to Frame 13: 1. c 2. a

Frame 15

The signal that causes the servomotor to drive up or down scale is decided at the chopper. When the DC signal voltage produced by the thermocouple circuit is greater than the DC feedback voltage felt on the wiper of the potentiometer R1, the servomotor drives to position the tape up scale due to the phasing of the AC output signal from the chopper. When the DC feedback signal is greater than the DC signal from the thermocouples (decrease in EGT), the motor drives to position the tape down scale due to phasing of the output AC signal from the chopper.

Circle the letter of the correct response to the following statement.

1. The servomotor drives the tape down scale when the DC signal from the thermocouple circuit is

   a. less than the signal from potentiometer R1.
   b. greater than the signal from potentiometer R1.
   c. the same as the signal from potentiometer R1.

Answers to Frame 14: 1. b 2. c

Answer to Frame 15: 1. a

Take appraisal for section B.

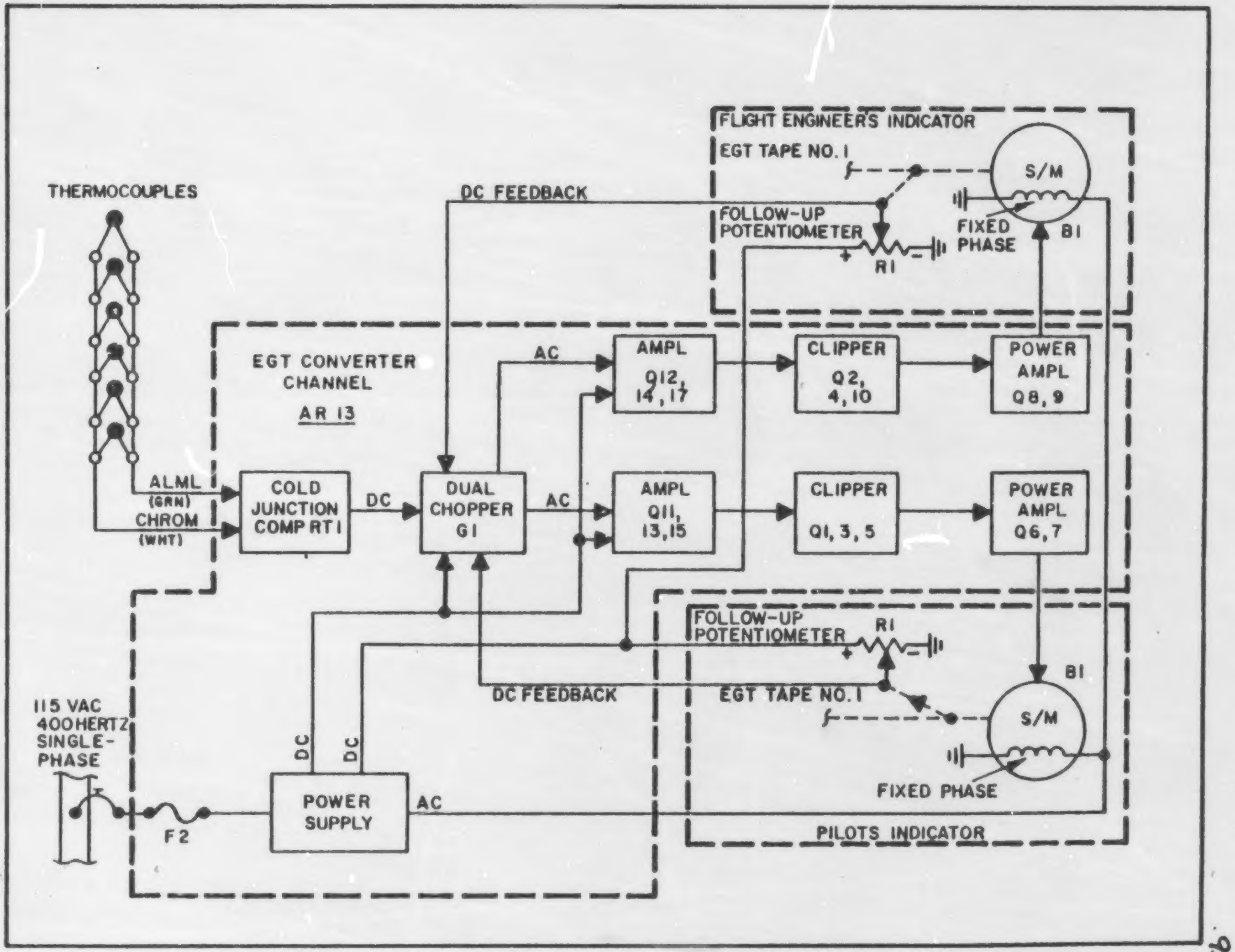

THERMOCOUPLES
ALML
(GRN)
CHROM
(WHT)
EGT CONVERTER CHANNEL
AR 13
COLD JUNCTION COMP RT1
DC
DUAL CHOPPER G1
DC FEEDBACK
AC
AMPL Q12, 14, 17
AMPL Q11, 13, 15
CLIPPER Q2, 4, 10
CLIPPER Q1, 3, 5
POWER AMPL Q8, 9
POWER AMPL Q6, 7
FLIGHT ENGINEERS INDICATOR
EGT TAPE NO. 1
S/M
FOLLOW-UP POTENTIOMETER
+
R1
-
FIXED PHASE
B1
PILOTS INDICATOR
115 VAC
400 HERTZ
SINGLE-PHASE
F2
POWER SUPPLY
DC
DC
AC

Figure 8.

993

994

Section C

Frame 1

The vertical scale engine instrument fuel flow indicators provide the pilot and flight engineer with indications of rate of fuel flow to the engines in pounds per hour (PPH). These new tape-type instruments present the same information to the pilot and flight engineer as do the dial-type instruments covered in earlier programmed texts. However, the tape-type instruments have two distinct advantages over the dial-type. They take up less space and are easier for the pilot and flight engineer to read at a glance. The fuel flow indications for all four engines are shown on one instrument. See figures 1 and 2.

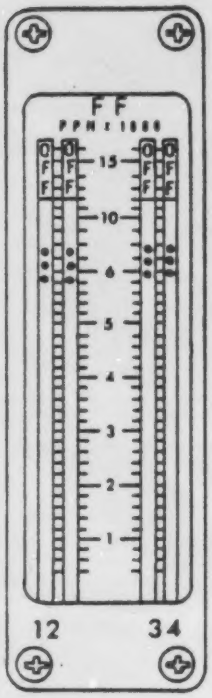


Figure 1.

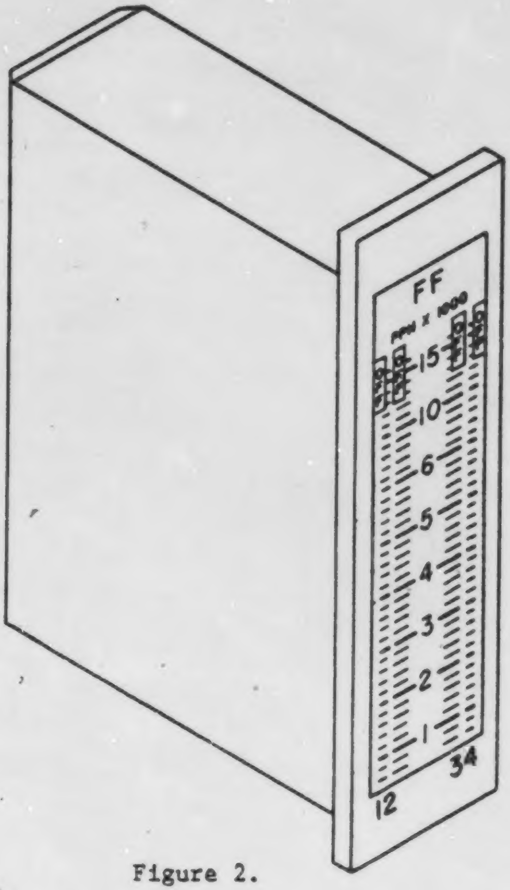


Figure 2.

For each of the following statements, circle the letter preceding the correct alternative.

1. The advantages of the tape-type instrument, over the dial-type, are that the tape-type requires
   - a. more space and is easier to read.
   - b. less space and is easier to read.
   - c. less space and is harder to read.
   - d. the same amount of space and is easier to read.

2. The instrument shown in figures 1 and 2 indicates the fuel flow for

   a. 1 engine.
   b. 2 engines.
   c. 3 engines.
   d. 4 engines.

3. The vertical scale fuel flow indicating system indicates the amount of fuel flow in

   a. pounds per inch X 1000.
   b. pounds per minute X 1000.
   c. pounds per hour X 1000.
   d. gallons per hour X 1000.

996

Frame 2

The vertical scale engine instrument fuel flow system consists of the engine-mounted signal-producing components, the converter unit, and the indicator. Figure 3 shows the transmitter, figure 4 shows the converter, and figure 5 shows the indicator. The signal producing component is the transmitter. Each engine has a fuel flow transmitter (sensor), that is mounted on or near the engine. Since system operation begins with the signal produced by the signal-sensing component, that is the first item we will learn about.

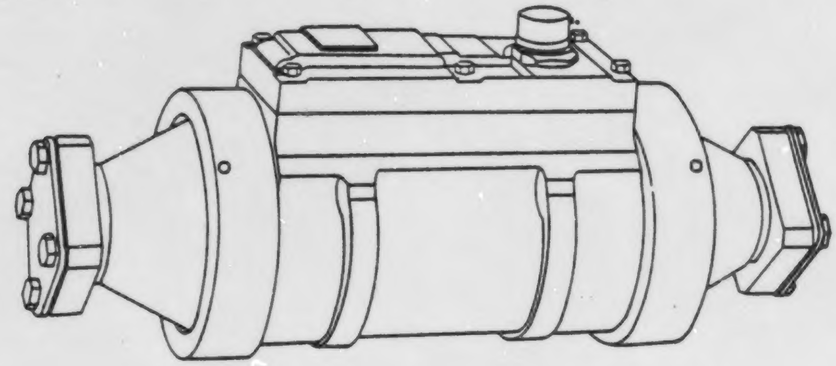


Figure 3.

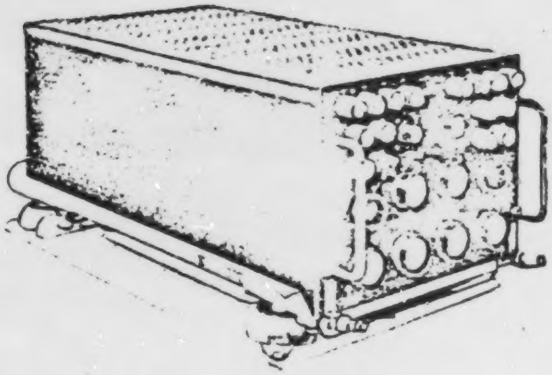


Figure 4.

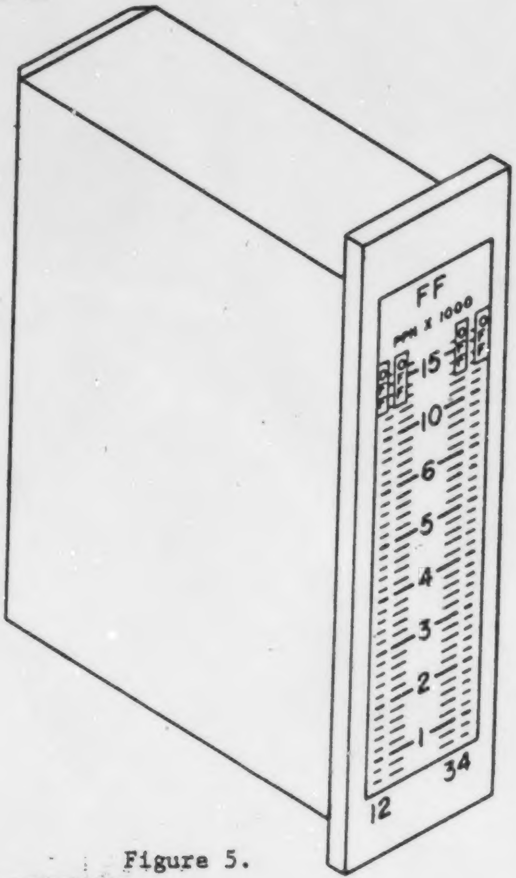


Figure 5.

NO RESPONSE REQUIRED

Answers to Frame 1: 1. b 2. d 3. c

Frame 3

The fuel flow transmitter shown in figure 3 differs greatly from the fuel flow transmitter you studied in an earlier programmed text. However, the signal output to the fuel flow indicating system is the same. The transmitter (TX) provides a synchro signal output to the system. This signal is applied directly to the control transformer (CT) in the indicators. See figure 6 (next page). The angular position of the synchro rotor is directly proportional to the rate of fuel flow.

Refer to figure 6 to complete the following statement. Circle the letter preceding the correct response.

1. The signal from the fuel flow transmitter is applied to the

   a. servomotor.
   b. power supply.
   c. transmitter motor.
   d. control transformer synchro.

Frame 4

The transmitter operates on the principle that the amount of fluid flow can be measured by its resistance to deflection. The transmitter receives 115V AC 400-Hertz single-phase power from the converter unit. This AC power is supplied to a motor in the transmitter. See figure 6. The motor drives an impeller, in the transmitter, at a constant speed of 60 revolutions per minute.

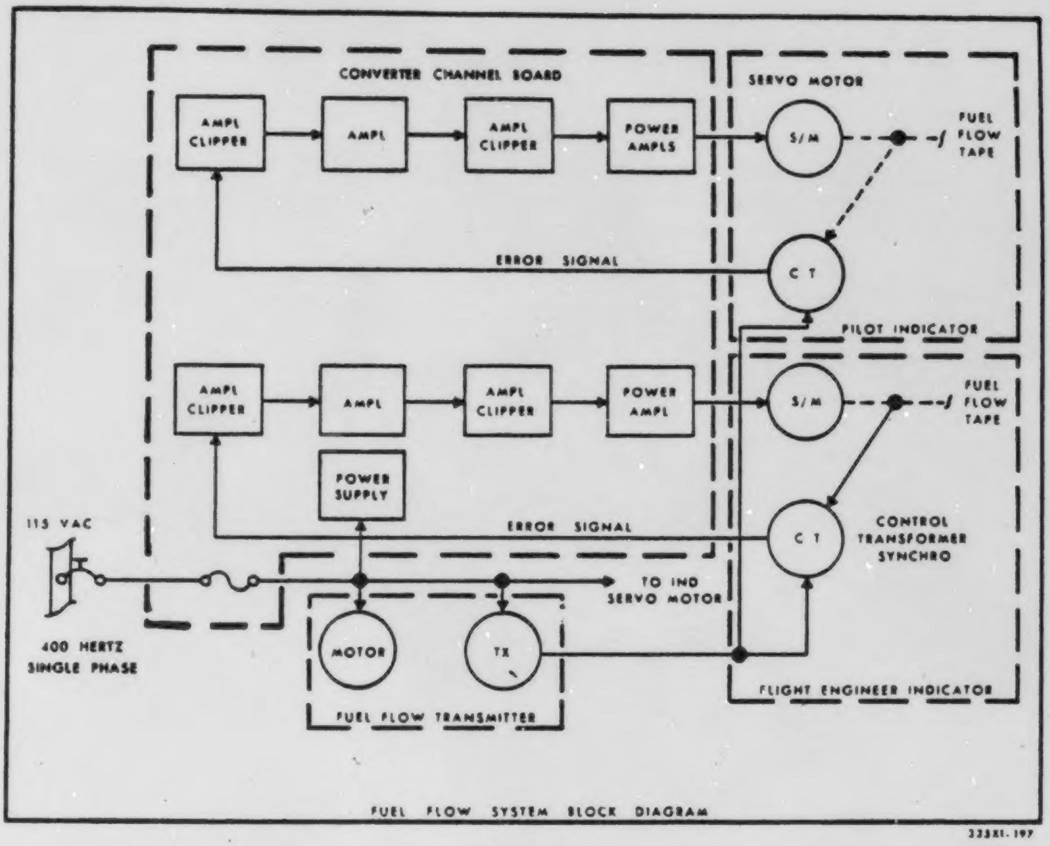

CONVERTER CHANNEL BOARD
SERVO MOTOR
AMPL CLIPPER
AMPL
AMPL CLIPPER
POWER AMPLS
S/M
FUEL FLOW TAPE
ERROR SIGNAL
C T
PILOT INDICATOR
AMPL CLIPPER
AMPL
AMPL CLIPPER
POWER AMPL
S/M
FUEL FLOW TAPE
POWER SUPPLY
115 VAC
ERROR SIGNAL
C T
CONTROL TRANSFORMER SYNCHRO
TO IND SERVO MOTOR
400 HERTZ SINGLE PHASE
MOTOR
TX
FUEL FLOW TRANSMITTER
FLIGHT ENGINEER INDICATOR
FUEL FLOW SYSTEM BLOCK DIAGRAM
333XI.197

Figure 6.

Refer to figure 6 to complete the following statement. Circle the letter preceding the correct alternative.

1. The transmitter motor operates on

   a. 115V AC.
   b. 110V AC, 60 Hertz, three-phase.
   c. 115V AC, 400 Hertz, single-phase.
   d. 115V AC, 400 Hertz, three-phase.

Answer to Frame 3: 1. d

Frame 5

As the fuel flows into the transmitter through the inlet vane, the motor driven impeller causes the fuel to swirl. The torque created by the swirling fuel causes the moveable turbine to be moved against a restraining spring. When the torque applied to the turbine equals the resistance of the retstraining spring, the turbine movement stops. The movement of the turbine, through magnetic coupling, positions the rotor of the synchro unit. If something should happen that the motor could not drive the impeller, the system would be inoperative and the indicator would show no fuel flow.

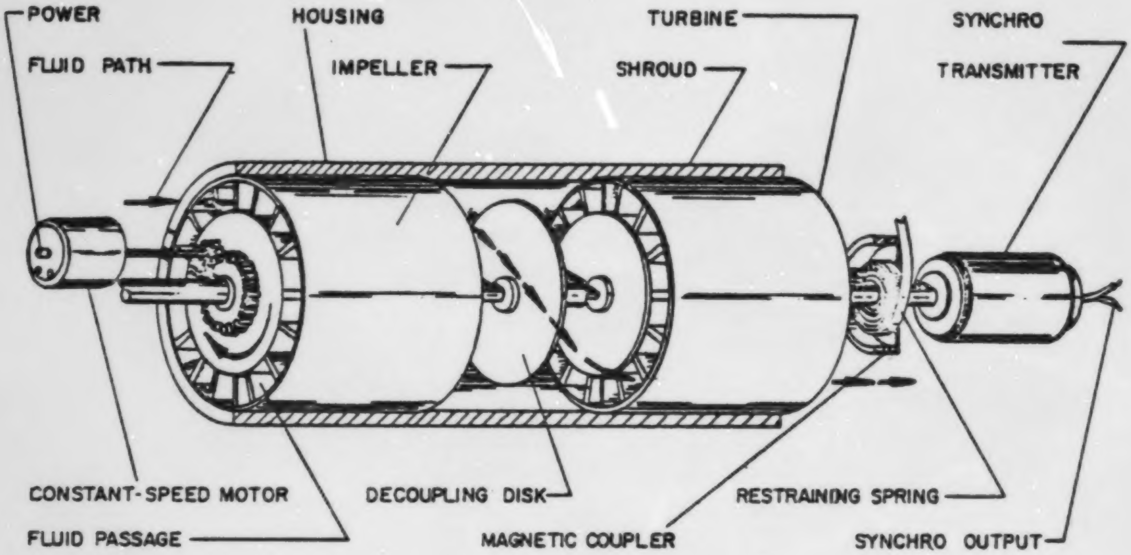

POWER
FLUID PATH
HOUSING
IMPELLER
TURBINE
SHROUD
SYNCHRO
TRANSMITTER
CONSTANT-SPEED MOTOR
FLUID PASSAGE
DECOUPLING DISK
MAGNETIC COUPLER
RESTRAINING SPRING
SYNCHRO OUTPUT

Figure 7.

Refer to figure 7 to complete the following statements. For each statement circle the letter preceding the correct alternative.

1. The moveable turbine positions the rotor of the synchro through
   a. a mechanical linkage.
   b. a magnetic coupling.
   c. an electromagnetic coupling.

2. The turbine movement is stopped by
   a. a restraining spring.
   b. a magnetic brake assembly.
   c. an electric brake assembly.

3. If the constant speed motor in the transmitter burns out, the impeller will not rotate. The fuel flow indication will show
   a. normal.
   b. high.
   c. no fuel flow.
   d. low.

Answer to Frame 4: 1. c

1,000

Frame 6

The converter unit, shown in figure 8, is a shock mounted transistorized unit containing 16 channel boards. The fuel flow channel boards contain the conversion circuitry and amplifiers necessary to operate the vertical scale indicating systems. Input signals to the fuel flow channel boards are supplied by the control transformers in the indicators.

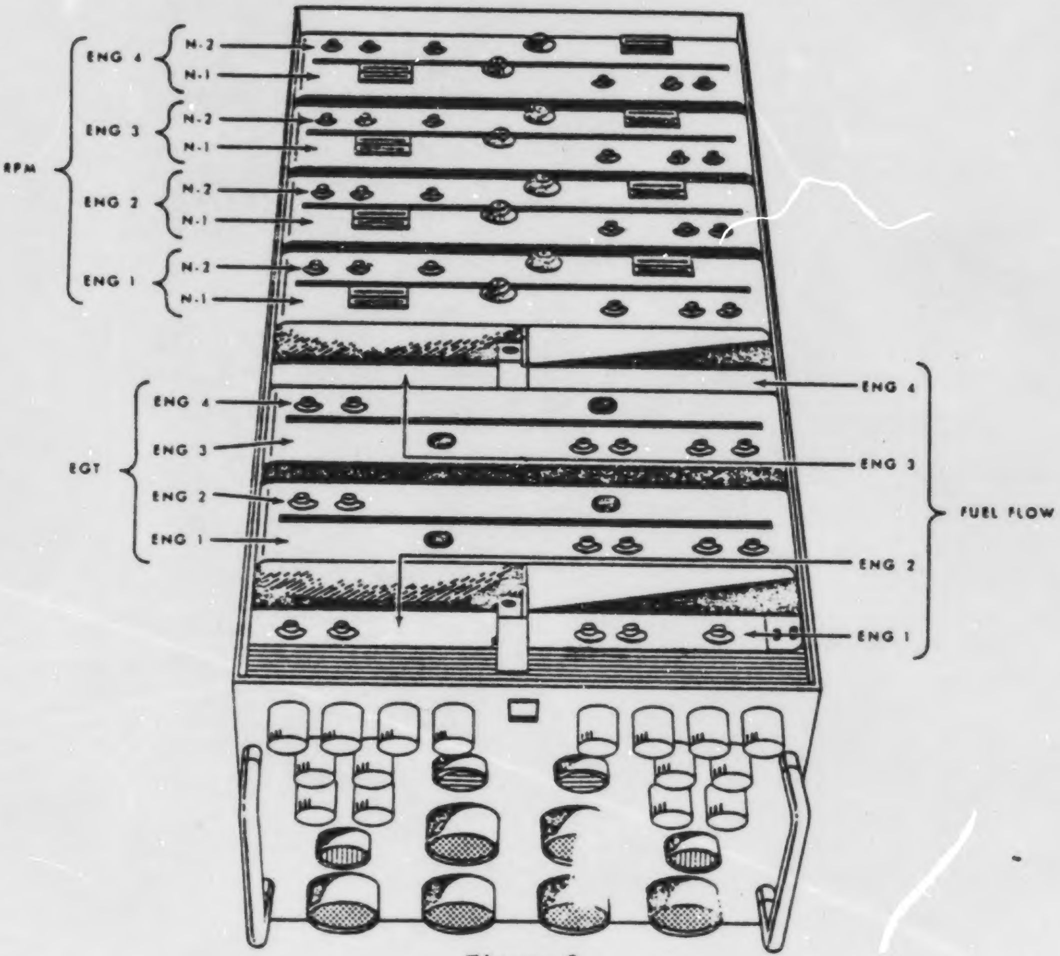

RPM
ENG 4
N-2
N-1
ENG 3
N-2
N-1
ENG 2
N-2
N-1
ENG 1
N-2
N-1
EGT
ENG 4
ENG 3
ENG 2
ENG 1
FUEL FLOW
ENG 4
ENG 3
ENG 2
ENG 1

Figure 8.

Refer to figure 8 to answer the following question. Circle the letter preceding the correct answer.

1. The converter contains how many channel boards for the fuel flow system?

   a. 2.
   b. 4.
   c. 6.
   d. 8.

Answers to Frame 5: 1. b 2. a 3. c

Frame 7

FOUR fuel flow channel boards are used in the converter unit. These channel boards are interchangeable with each other.

There is ONE fuse for each of the FOUR fuel flow channels of the converter unit. The fuse number and the circuit that it protects (FF = fuel flow) are printed on the top of the converter unit. See figure 9 for fuse locations.

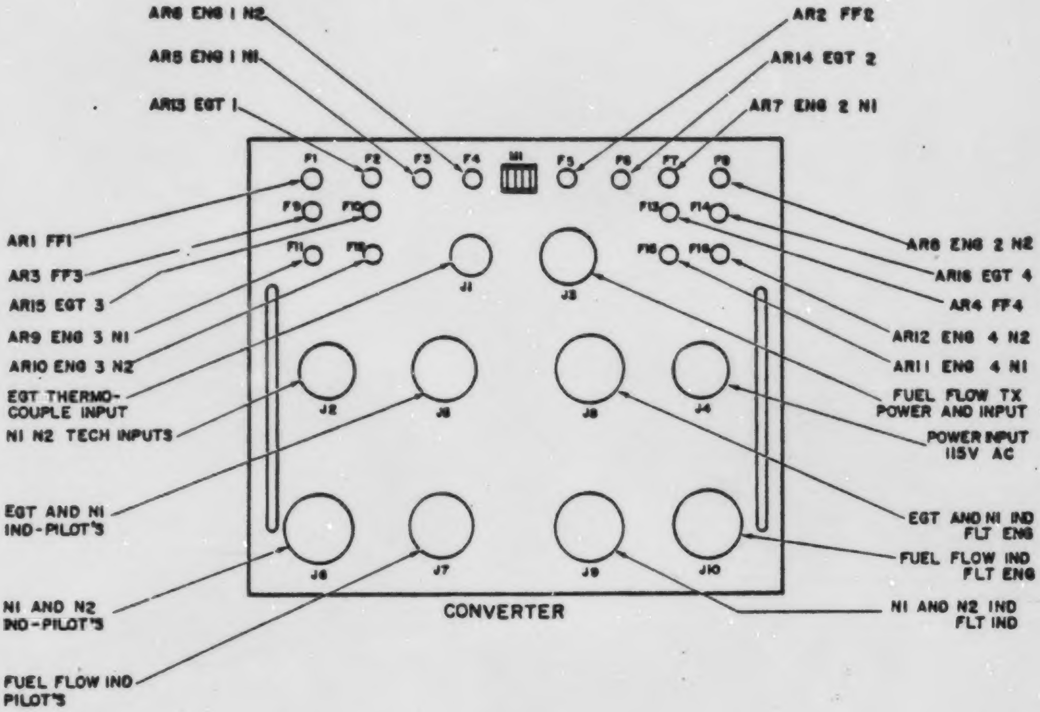

AR6 ENG 1 N2
AR5 ENG 1 N1
AR13 EGT 1
AR2 FF2
AR14 EGT 2
AR7 ENG 2 N1
F1
F2
F3
F4
M1
F5
F6
F7
F8
F9
F10
F11
F12
F13
F14
F15
F16
J1
J3
J2
J5
J8
J4
J6
J7
J9
J10
AR1 FF1
AR3 FF3
AR15 EGT 3
AR9 ENG 3 N1
AR10 ENG 3 N2
EGT THERMO-COUPLE INPUT
N1 N2 TECH INPUTS
EGT AND N1 IND-PILOT'S
N1 AND N2 IND-PILOT'S
FUEL FLOW IND PILOT'S
AR8 ENG 2 N2
AR16 EGT 4
AR4 FF4
AR12 ENG 4 N2
AR11 ENG 4 N1
FUEL FLOW TX POWER AND INPUT
POWER INPUT 115V AC
EGT AND N1 IND FLT ENG
FUEL FLOW IND FLT ENG
N1 AND N2 IND FLT IND
CONVERTER

Figure 9.

Refer to figure 9 to complete the following statement. For each statement, circle the letter preceding the correct alternative.

1. The number 1 engine fuel flow system is protected by fuse number

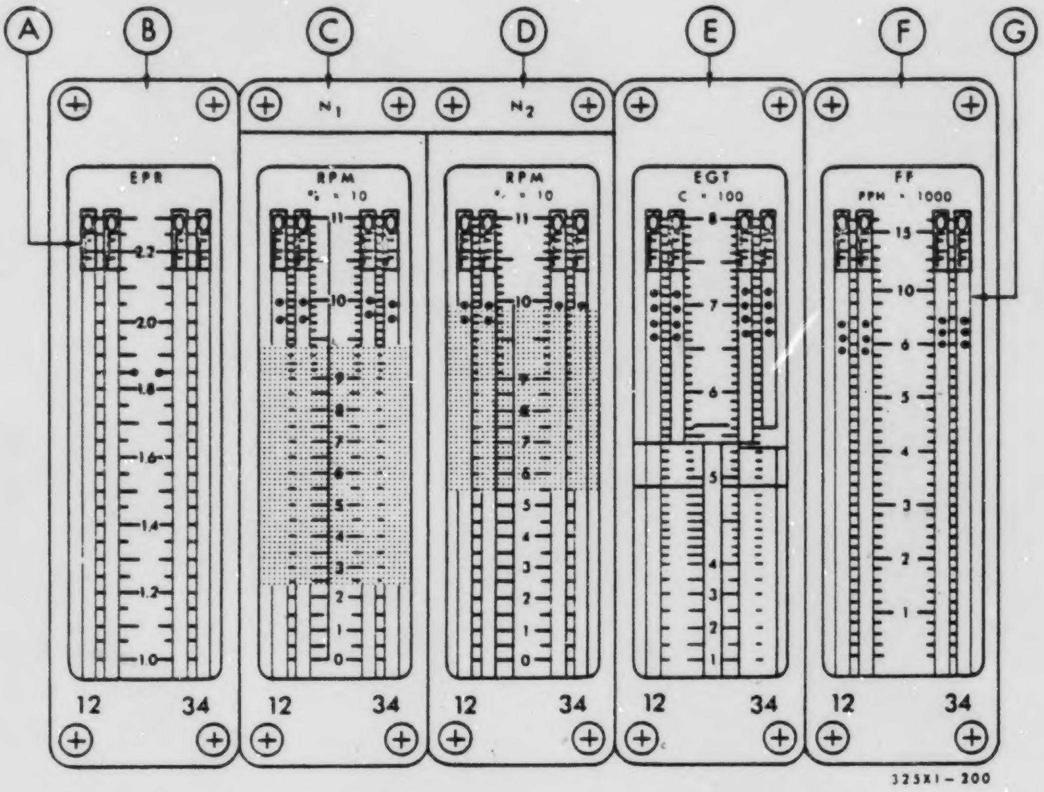
   a. F1.
   b. F2.
   c. F9.
   d. F13.

Answer to Frame 6: 1. b

1002

Frame 8

A typical arrangement of the vertical scale engine indicators as they might appear on the instrument panel is shown in figure 10. Note that the fuel flow indications for ALL FOUR engines appear on FOUR separate tapes inside ONE indicator (F). These vertical scale indicators are internally lighted. The scale ranges from 0 PPH to 16,000 PPH, on the fuel flow indicator.



A. POWER OFF INDICATORS
B. ENGINE PRESSURE RATIO INDICATOR
C. TACHOMETER (RPM) INDICATOR (N_1)
D. TACHOMETER (RPM) INDICATOR (N_2)
E. EXHAUST GAS TEMPERATURE INDICATOR
F. FUEL FLOW INDICATOR
G. MOVABLE TAPES

Figure 10.

Circle the letter preceding the correct alternative.

1. The vertical scale engine instruments are lighted

   a. internally.
   b. externally.
   c. by indirect lighting.
   d. by fluorescent lighting.

Answers to Frame 7: 1. a

Frame 9

Two identical sets of the vertical scale indicators are used in the engine instrument system. One set is mounted on the pilot's engine instrument panel and the other set is mounted on the flight engineer's panel. The word "OFF" appears at the top of all the indicators when power is not applied to the system.

Refer to figure 10 to complete the following statement. Circle the letter preceding the correct alternative.

1. When power is removed from the instrument system, the word OFF appears on the pilot's and flight engineer's

   a. indicator fuse panel.
   b. indicator transmitters.
   c. indicators.

Answer to Frame 8: 1. a

Frame 10

The tape is mechanically positioned by the gear train and two tape drums. The tape threading route and the tape drums are shown in figure 11. When the gear train is turned by the servomotor, the tape drum rotates in the direction shown. The small take-up drum rotates at the same time, in the direction shown.

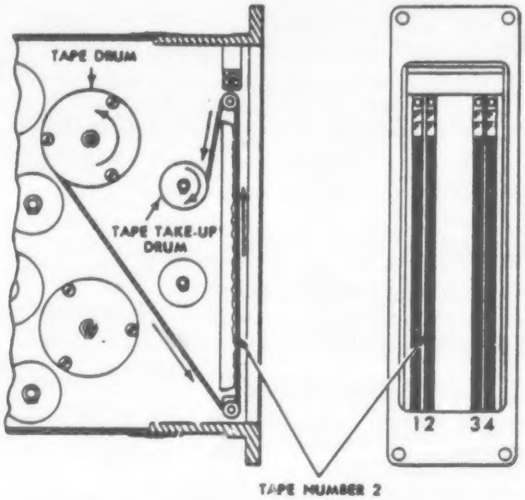


Figure 11.

Refer to figure 11 to complete the following statement. Circle the letter preceding the correct alternative.

1. The tape shown in figure 11 is tape number

   a. 1.
   b. 2.
   c. 3.
   d. 4.

Answer to Frame 9: 1. c

The fuel flow indicator is constructed almost identical to the indicators we have discussed thus far. The major difference is that a control transformer is incorporated in each indicator tape gear train to NULL the servoloop operation. See figure 14 in the back of section C (page 70). The control transformer NULLS the error signal. This difference will be studied later under system operation.

Refer to figure 14 to complete the following statement. Circle the letter preceding the correct alternative.

1. The servoloop operation of the fuel flow indicating system is nulled by

   a. a DC potentiometer.
   b. a control transformer.
   c. an AC potentiometer.
   d. an AC resistive bridge circuit.

Answer to Frame 10: 1. b

1006

Frame 12

Each tape in the indicator shows the rate of fuel flow for its respective engine. These indicators are calibrated to indicate the fuel flow in pounds per hour X 1000. The tape is read against a calibrated scale. The indicator has a range from 400 to 16,000 PPH. Look at figure 12. Each numbered increment is read as PPH fuel flow X 1000. From 400 to 6000 PPH the scale is calibrated in 200 PPH increments. From 6000 PPH to 16,000 PPH the scale is calibrated in 1000 PPH increments.

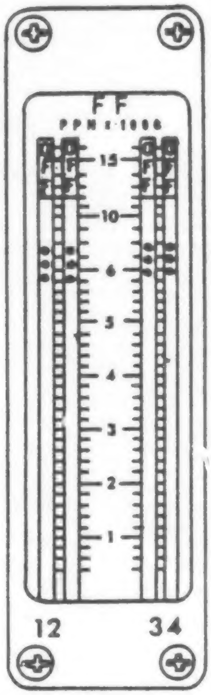


Figure 12.

Complete each statement below by circling the letter preceding the correct response.

1. The vertical scale fuel flow indicator shown in figure 12 will indicate the amount of fuel flow in pounds per
   - a. second times 1000.
   - b. minute times 1000.
   - c. hour times 1000.

2. The numbered increments of the vertical scale fuel flow indicator are calibrated to indicate
   - a. percent of fuel flow X 1000.
   - b. pounds per hour of fuel flow X 1000.
   - c. pounds per second of fuel flow X 1000.
   - d. pounds per minute of fuel flow X 1000.

Answer to Frame 11: 1. b

The fuel flow indicating system is a servo-driven synchro-controlled system and is referred to as a servoloop system. The indicator consists of four independent tape indicators. Again you are reminded that all four indicating systems operate the same. So you need to learn about only ONE fuel flow indicating system. To establish a beginning point, we will set up the same conditions that were established for the other tape systems. There is no power applied and the engines are not running. Refer to figure 14 at the back of section C to answer the questions on the next ten (10) frames.

Refer to figure 14 to complete the following statement. Circle the letter preceding the correct alternative.

1. The vertical scale fuel flow indicating system is referred to as a

   a. servoloop system.
   b. DC potentiometer feedback system.
   c. resistance potentiometer feedback system.
   d. servo resistance bridge feedback system.

Answers to Frame 12: 1. c 2. b

Frame 14

Figure 14 shows a block diagram of a fuel flow indicating system for the pilot's and flight engineer's indicators. Since this diagram shows fuse F1, which is located in the converter, the circuit is identified as the number 1 fuel flow indicating system. When the circuit breaker is closed and 115V AC power is applied to the aircraft bus bar, this power passes through fuse F1 to a junction. From this junction, the 115V AC is applied to the amplifier power supply and down to the fuel flow transmitter motor. Follow the same wire from the junction to the right and you will see that the 115V AC is also applied to the fuel flow transmitting synchro (TX). From the junction just above the fuel flow transmitter (TX), the AC voltage is applied to the servomotors of the pilot's and flight engineer's fuel flow indicators.

Answer the following question by circling the letter preceding the correct answer.

1. What is the power requirement of the fuel flow indicating system?

   a. 28V DC.
   b. 28V AC, 400-Hertz, single-phase.
   c. 115V AC, 60-Hertz, three-phase.
   d. 115V AC, 400-Hertz, single-phase.

Answer to Frame 13: 1. a

The power supply furnishes the regulated DC voltage necessary for amplifier operation. The 115V AC is supplied to the fuel flow transmitter motor. The motor drives the impeller at a constant speed of 60 rpm. This same 115V AC is applied to the transmitter (TX) for rotor excitation and to the fixed phase of the servomotors, as a reference voltage.

Circle the letter preceding the correct statement.

1. The 115V AC is applied to the transmitter motor to drive the

   a. servomotor at a speed of 60 rpm.
   b. impeller at a speed of 60 rpm.
   c. transmitter rotor at a speed of 60 rpm.

Answer to Frame 14: 1. d

Frame 16

When power is applied to the system, a signal is induced into the stators of the transmitter (TX). This signal is transferred electrically, to the stators of the control transformer (CT), in the pilot's and flight engineer's indicators. See figure 14. From this point on, the pilot's and flight engineer's circuits are independent but the circuit operation is identical. So we will discuss the pilot's indicating system.

NO RESPONSE REQUIRED

Answer to Frame 15: 1. b

Frame 17

The fuel flow transmitter output signal bypasses the fuel flow converter channel board and is supplied directly to the fuel flow indicator. See figure 14. The signal is received by a control transformer (CT) in the indicator. The error signal, that is induced into the rotor of the control transformer, is sent to an amplifier clipper located on the fuel flow converter channel board. The channel board contains the circuitry necessary to amplify, clip, and power the error signal that drives the indicator servomotor.

For each statement, circle the letter preceding the correct response.

1. The fuel flow transmitter output signal is sent directly to

   a. the servomotor.
   b. the control transformer.
   c. an amplifier.
   d. an amplifier clipper.

2. The signal amplifying section is located

   a. on the converter channel board.
   b. in the fuel flow indicator.
   c. in the fuel flow transmitter.
   d. in the AC power supply.

Frame 18

When the signal from the stators of the transmitter (TX) is felt in the stators of the pilot's indicator (CT), a small error signal is induced into the rotor of the (CT). The error signal from the rotor is applied to the circuits of the amplifier clipper. The clipped signal is then amplified and sent to another amplifier clipper. Again the signal is clipped and sent to the power amplifier. The output from the power amplifier is fed to the control phase of the indicator servomotor.

For each statement, circle the letter preceding the correct response.

1. The error signal induced into the rotor of the pilot's CT is sent directly to

   a. the power supply.
   b. an amplifier clipper.
   c. the power amplifier.
   d. the servomotor.

2. The error signal sent to the fuel flow converter channel board is clipped and

   a. converted to a square wave DC signal.
   b. amplified, clipped and increased in power.
   c. amplified to a square wave DC signal.
   d. converted to smooth 400 Hertz AC signal.

Answers to Frame 17: 1. b 2. a

When the control phase of the servomotor is energized, the motor starts to run. As the motor runs, the gear train in the indicator positions the tape. At the same time it turns the rotor of the CT toward the NULL position. The motor drives the gear train until the rotor of the CT is moved perpendicular to the resultant magnetic field. At this time, the rotor is NULLED and the error signal to the amplifier clipper is NULLED out. This causes the indicator motor to stop. The tape has now moved just enough to remove the word OFF from view. The indicator now appears blank except for the calibrated scale. See figure 14.

Circle the letter preceding the correct response.

1. The nulling signal to amplifier clipper is sent out by the

   a. transmitter.
   b. control transformer.
   c. power supply.
   d. servomotor.

Answers to Frame 18: 1. b 2. b

Frame 20

When an engine is started, fuel starts to flow through the transmitter. When fuel flows through the transmitter, the rotor of the transmitter TX is moved proportionately to the rate of flow increase through the transmitter. Since the rotor of the transmitter (TX) has moved, the stators of the TX now have different voltages induced. Since the stators of the indicator (CT) are directly connected to the stators of the TX, this change in stator voltage is felt on the stators of the CT. Now the rotor of the CT is no longer nulled and an error signal is induced into the rotor of the CT.

Circle the letter of the correct response.

1. The voltage from the transmitter is felt on the

   a. servomotor.
   b. amplifier clipper.
   c. control transformer stators.
   d. transmitter motor.

Answer to Frame 19: 1. b

Frame 21

The error signal from the rotor of the CT is applied to the circuits of the amplifier clipper. The clipped signal is then amplified and sent to another amplifier clipper. Again the signal is clipped and supplied to the power amplifier. The output from the power amplifier is fed to the control phase of the indicator servomotor. See figure 14.

Circle the letter preceding the correct response.

1. The error signal from the control transformer synchro is sent to

   a. the transmitter motor.
   b. the servomotor.
   c. an amplifier clipper.
   d. the transmitter synchro.

Answer to Frame 20: 1. c

1016.

Frame 22

When the control phase of the servomotor is energized, the servomotor starts to run. As the motor runs, the gear train in the indicator positions the tape upscale and at the same time turns the rotor of the CT toward the NULL position. The motor continues to run until the rotor of the CT is moved perpendicular to the resultant magnetic field. At this time, the rotor is at the NULL position and no error signal exists and the motor stops. The tape has been positioned to show the amount of fuel flow to the engines in pounds per hour (PPH).

Complete the following statement by circling the letter preceding the correct response.

1. The gear train shown by the dotted line in the pilot's indicator moves the

   a. servomotor.
   b. moveable tape.
   c. transmitter synchro.

Answer to Frame 21: 1. c

1140

If fuel flow through the transmitter decreases, a signal is induced opposite the phasing that causes the servomotor to drive upscale. This signal is induced into the rotor of the indicator (CT). The servomotor runs in the opposite direction and allows the spring to position the tape down scale and indicate a new amount of fuel flow.

Complete the following statement by circling the letter preceding the correct response.

1. The spring aids the motor in

    a. moving the tape upscale.
    b. moving the tape down scale.
    c. keeping the tape stationary.

Answer to Frame 22: 1. b

Frame 24

Inside the tape drum housing is a spiral spring. One end of the spring is locked to the tape drum shaft and the other is locked to the tape drum housing. When the tape drum is rotated, in the direction of the arrow by the gear train, the tension on the spring is increased. When power to the system fails, the tension of the spiral spring causes the gear train and the tape drums to rotate in the opposite direction. The tape unwinds until the word OFF appears at the top of the indicator.

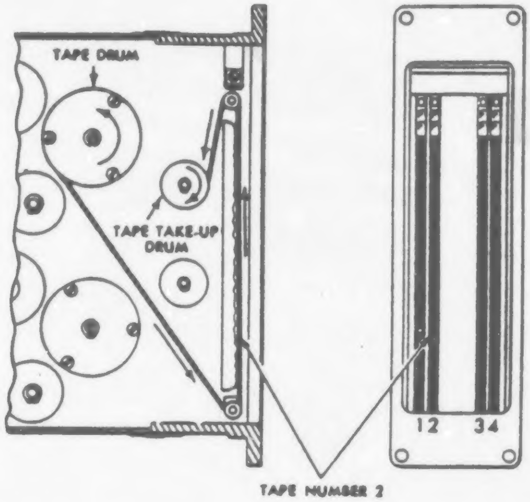


Figure 13.

Complete the following statement by circling the letter preceding the correct response.

1. The unit in the indicator that returns the tape to OFF when there is a loss of power is the

   a. synchro motor.
   b. AC motor.
   c. spiral spring.
   d. servomotor.

Answer to Frame 23: 1. b

Answer to Frame 24: 1. c

Take appraisal for section C.

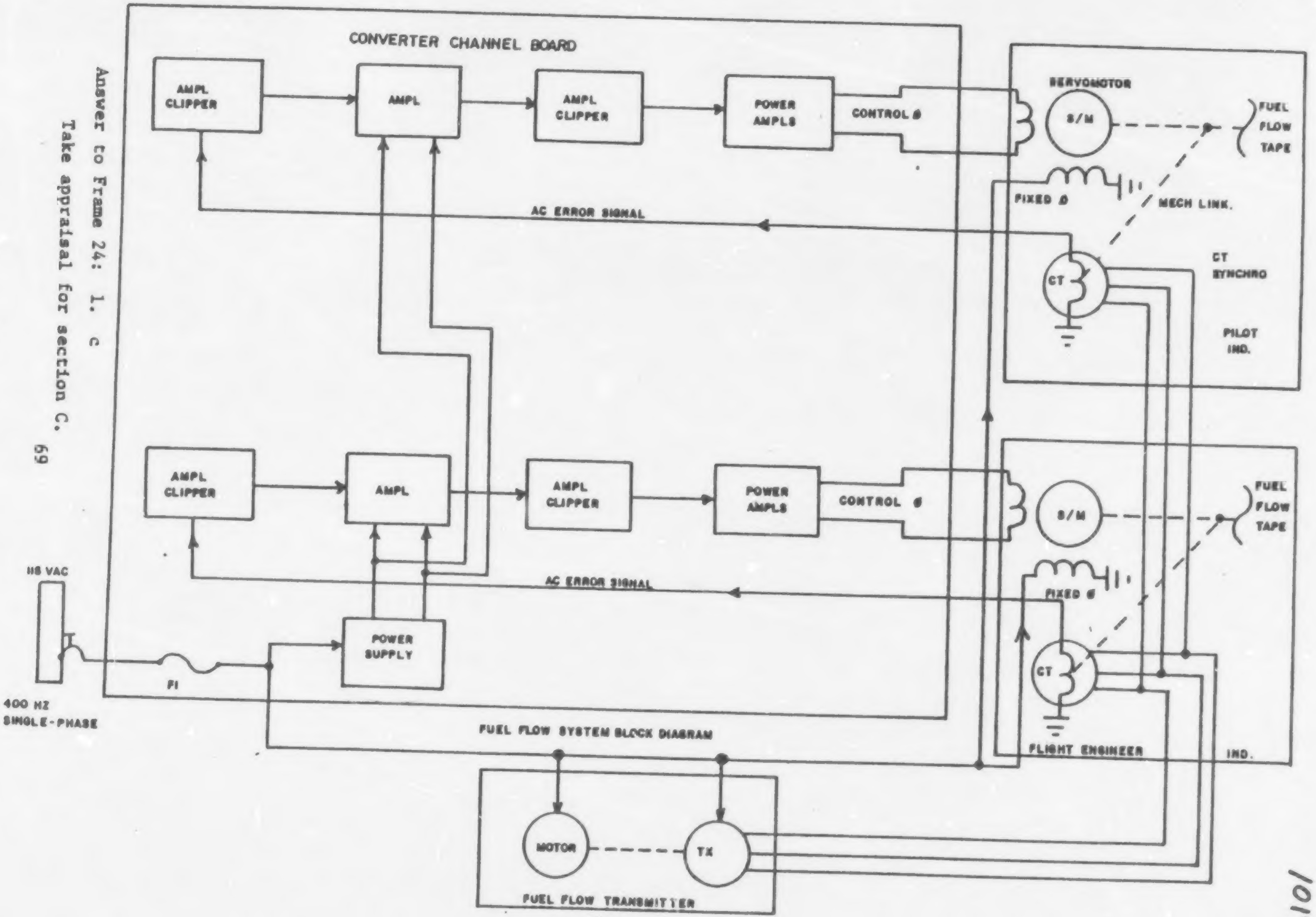

CONVERTER CHANNEL BOARD
AMPL CLIPPER
AMPL
AMPL CLIPPER
POWER AMPLS
CONTROL Ø
SERVOMOTOR
S/M
FUEL FLOW TAPE
FIXED Ø
MECH LINK.
AC ERROR SIGNAL
CT
CT SYNCHRO
PILOT IND.
AMPL CLIPPER
AMPL
AMPL CLIPPER
POWER AMPLS
CONTROL Ø
S/M
FUEL FLOW TAPE
FIXED Ø
AC ERROR SIGNAL
CT
FLIGHT ENGINEER IND.
115 VAC
400 HZ SINGLE-PHASE
F1
POWER SUPPLY
FUEL FLOW SYSTEM BLOCK DIAGRAM
MOTOR
TX
FUEL FLOW TRANSMITTER

Figure 14.

1019

Section D

Frame 1

The vertical scale engine pressure ratio indicating system provides the pilot and flight engineer with indications of the engine pressure ratio (EPR) on FOUR tapes. This V/S EPR indicating system consists of the engine-mounted, signal producing units (transducer) as shown in figure 1 and the vertical scale indicators as shown in figure 2.

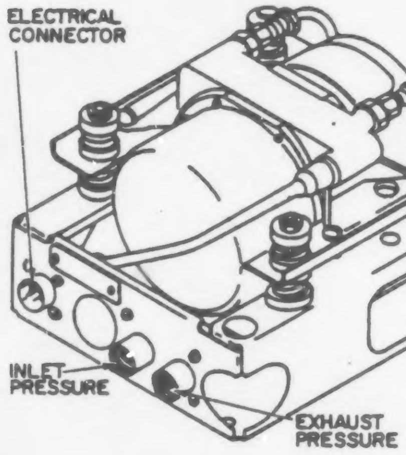

ELECTRICAL CONNECTOR
INLET PRESSURE
EXHAUST PRESSURE

Figure 1.

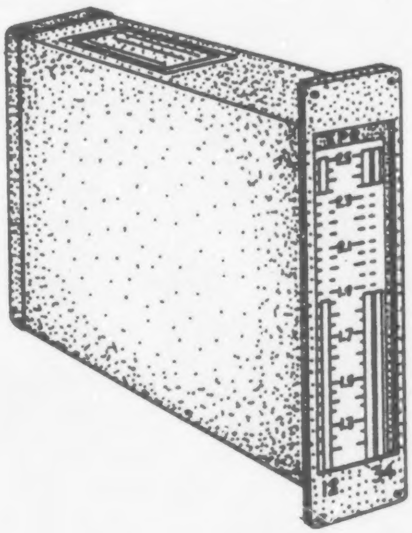


Figure 2.

NO RESPONSE REQUIRED

1021

Frame 2

The EPR transducer used in the vertical scale engine pressure ratio indicating system is similar in construction to the ones you studied in an earlier programmed text; see figure 3 (Air Research) and figure 4 (Minneapolis-Honeywell). The operating voltage, 115V AC 400-Hz single-phase of the EPR system is sensed by an LC filter and bridge network in the transducer. The transducer is used to provide a synchro signal output to operate the EPR indicator.

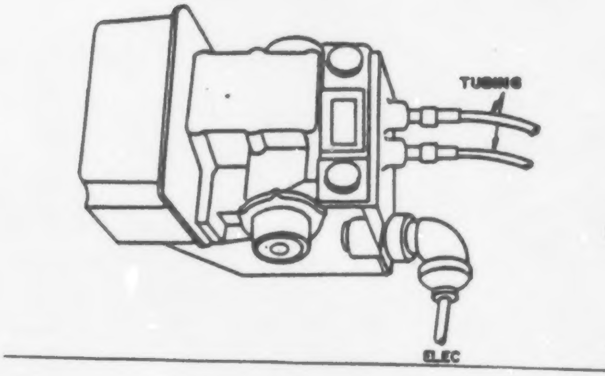


Figure 3.

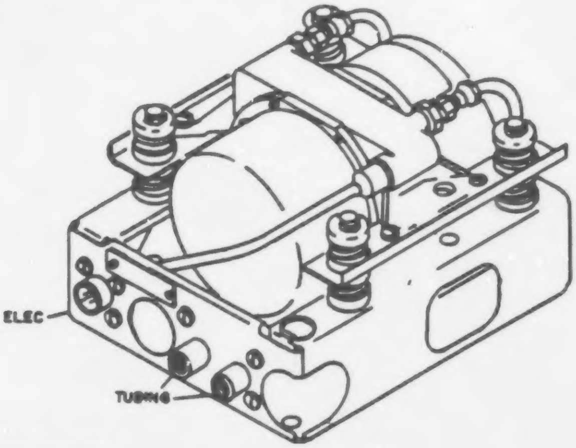


Figure 4.

Circle the letter of the correct answer.

1. The operating voltage required for the V/S EPR indicator system is

   a. 28V DC.
   b. 115V AC 60-Hz single-phase.
   c. 115V AC 400-Hz single-phase.
   d. 115V AC 400-Hz three-phase.

Frame 3

The EPR indicator is constructed slightly different from the V/S indicators we have discussed up to this time.

Unlike the other V/S systems, the V/S EPR system does not use the converter. The signals from the transducer are supplied directly to the EPR indicator (see figure 5). INPUTS to the transducer are PT_7 from ENGINE EXHAUST and PT_0 from ENGINE INLET pressures.

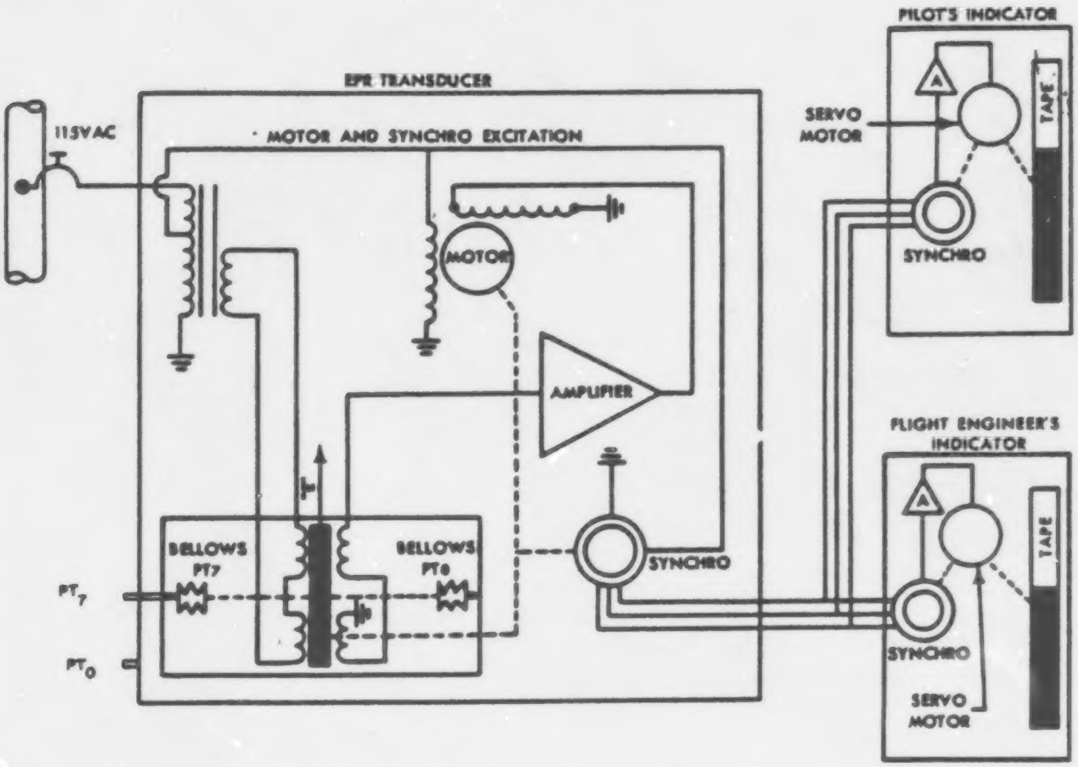

PILOT'S INDICATOR
EPR TRANSDUCER
115VAC
MOTOR AND SYNCHRO EXCITATION
SERVO MOTOR
A
TAPE
MOTOR
SYNCHRO
AMPLIFIER
FLIGHT ENGINEER'S INDICATOR
A
TAPE
BELLOWS PT7
BELLOWS PT0
SYNCHRO
PT_7
PT_0
SYNCHRO
SERVO MOTOR

Figure 5.

Refer to figure 5 to answer the following questions. Circle the letters of the correct statements.

1. The synchro in the transducer is connected to the indicator synchros by

   a. electrical wiring.
   b. a mechanical linkage.
   c. an electromagnetic connection.

2. The electrical signal sent to the EPR indicator is from the transducer's

   a. servomotor.
   b. synchro.
   c. amplifier.

Answer to Frame 2: 1. c

Frame 4

The EPR indicator (see figure 6) contains four complete servoloops. One servoloop operates each indicating tape. Each servoloop consists of a control transformer (synchro), amplifier, servomotor, rate generator, power supply and gear train. See figure 7 (next page). The gear train drives the rate generator, the rotor of the synchro and repositions the indicating tape. As the gear train turns the rotor, the synchro is moved to null out the signal from the EPR transducer.

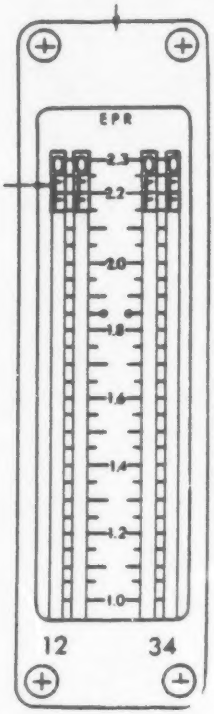


Figure 6.

Circle the letter of the correct statement below.

1. The rotor of the control transformer

   a. drives the motor.
   b. positions the tape.
   c. drives the amplifier.
   d. nulls out the signal from the EPR transducer.

Answers to Frame 3: 1. a 2. b

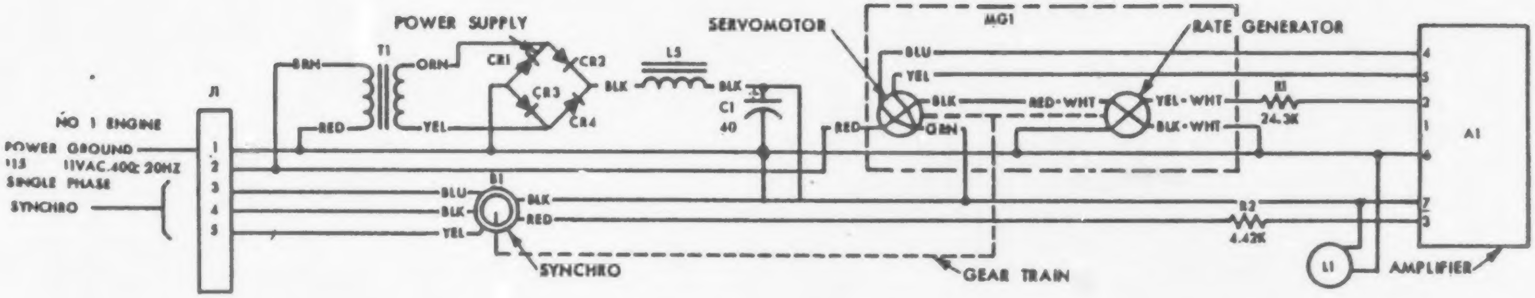

POWER SUPPLY
T1
BRN
RED
ORN
YEL
CR1
CR2
CR3
CR4
BLK
L5
BLK
C1
40
SERVOMOTOR
MG1
RATE GENERATOR
J1
NO 1 ENGINE
POWER GROUND
115 11VAC.400: 20HZ
SINGLE PHASE
SYNCHRO
1
2
3
4
5
B1
BLU
BLK
YEL
BLK
RED
SYNCHRO
RED
BLU
YEL
BLK
RED-WHT
YEL-WHT
BLK-WHT
GRN
R1
24.3K
R2
4.42K
GEAR TRAIN
L1
AMPLIFIER
A1
4
5
2
1
6
7
3

Figure 7.

1025

1026

Frame 5

A typical EPR indicator has a range of 1.0 to 2.3 units of EPR. The indicator is calibrated so that each increment represents 0.05 units of EPR. See figure 8. The indicator is used to show the units of EPR during engine operation.

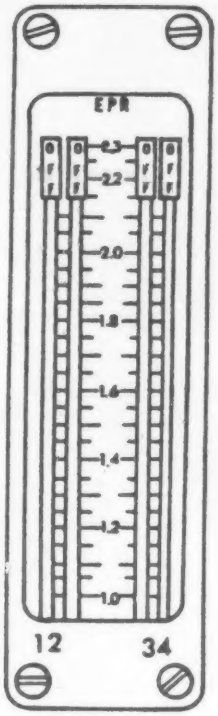


Figure 8.

Circle the letter of the correct statement.

1. The EPR indicator is used to sho

   a. RPM in percent.
   b. EPR units.
   c. temperature in degrees Celsius.
   d. fuel flow in pounds per hour.

Answer to Frame 4: 1. d

1052

Frame 6

The EPR indicating system for each engine consists of two independent servoloops. One servoloop, located in the transducer, senses the pressure ratio and positions the rotor of a synchro unit. The other servoloop, located in the indicator, receives the synchro signal from the EPR transducer and positions the indicating tape to show the EPR. Figure 9 shows a block diagram of the EPR indicating system for one engine. The EPR systems for the other engines operate identically.

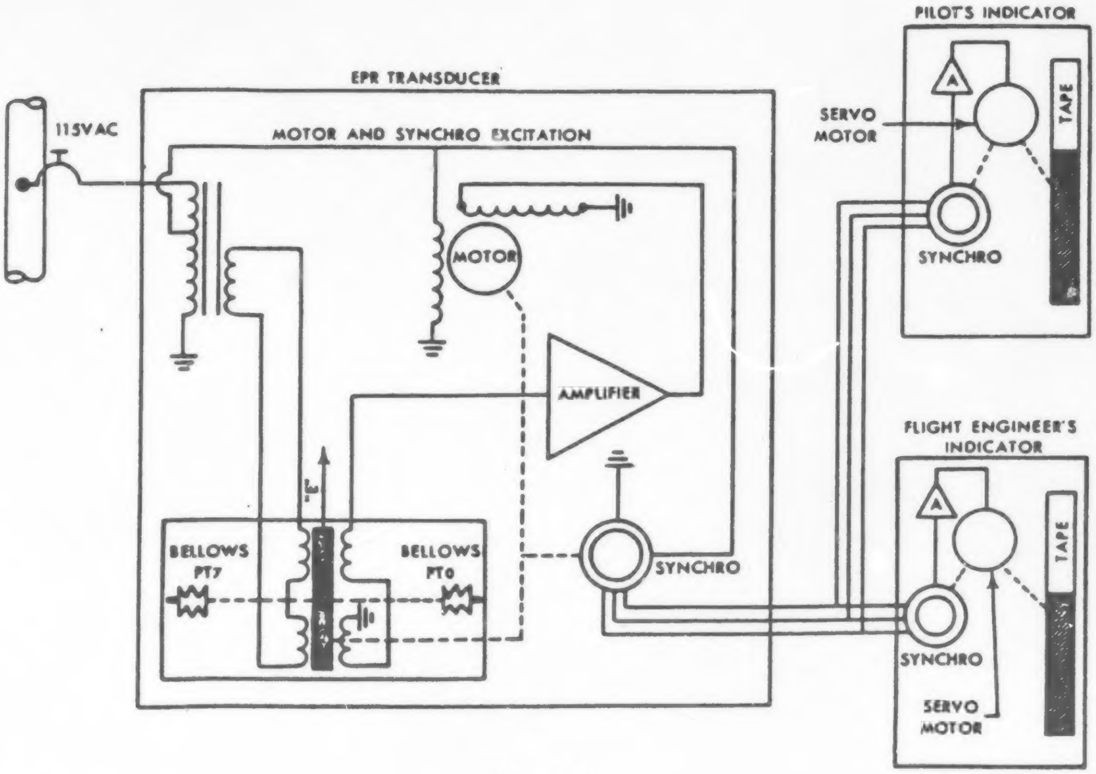

EPR TRANSDUCER
115VAC
MOTOR AND SYNCHRO EXCITATION
MOTOR
AMPLIFIER
BELLOWS PT7
BELLOWS PT0
SYNCHRO
PILOT'S INDICATOR
A
SERVO MOTOR
TAPE
SYNCHRO
FLIGHT ENGINEER'S INDICATOR
A
TAPE
SYNCHRO
SERVO MOTOR

Figure 9.

Circle the letters of the correct answers.

1. The EPR transducer contains

   a. one servoloop.
   b. two servoloops.
   c. three servoloops.
   d. four servoloops.

Frame 6 (Continued)

2. The indicator (for one engine) contains

   a. one servoloop.
   b. two servoloops.
   c. three servoloops.
   d. four servoloops.

3. The operation of the vertical scale EPR system is based on a

   a. servoloop circuit.
   b. potentiometer feedback circuit.
   c. capacitance feedback circuit.
   d. resistance feedback circuit.

Answer to Frame 5: 1. b

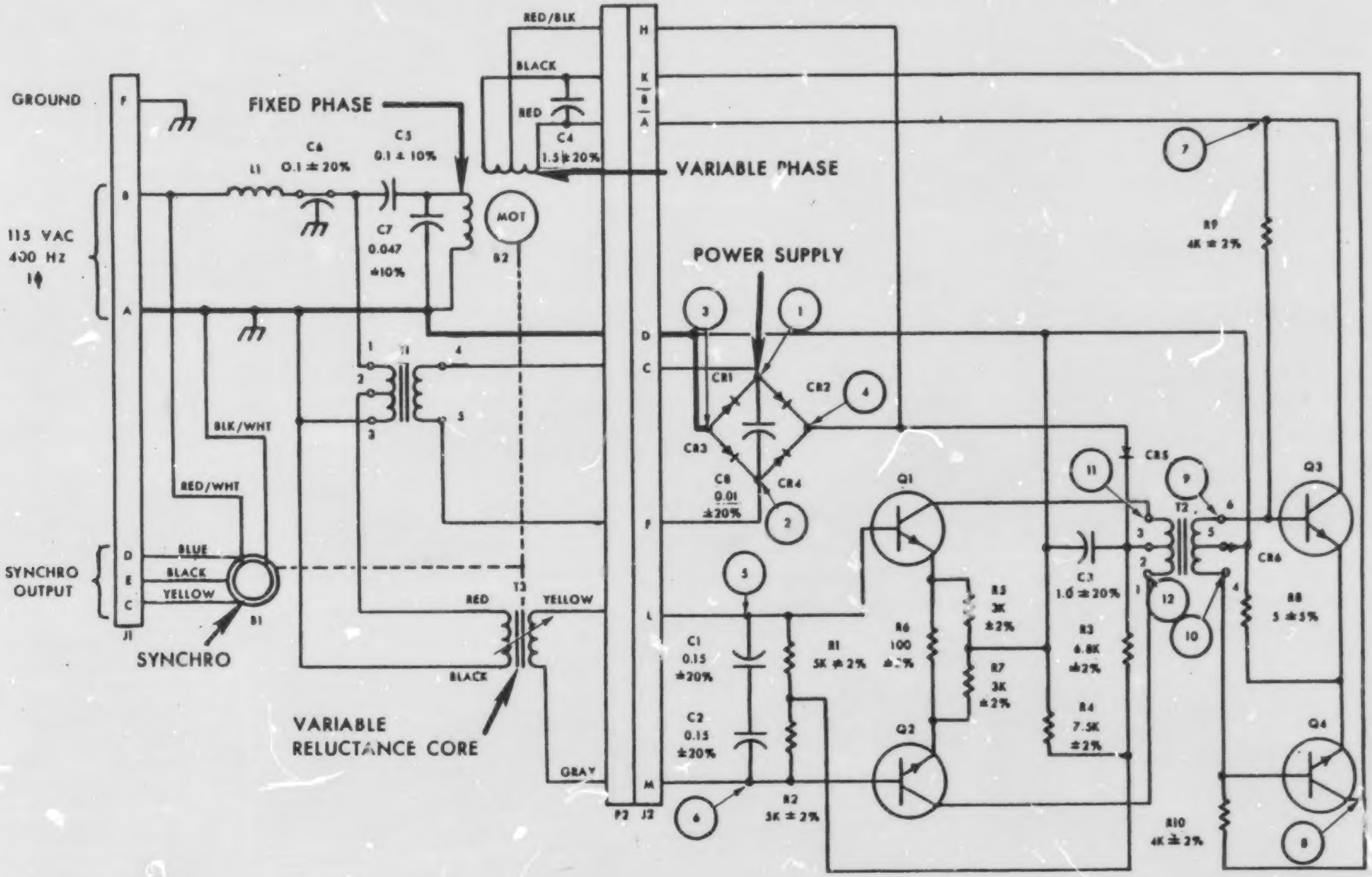

GROUND
F
FIXED PHASE
C6
0.1 ± 20%
C5
0.1 ± 10%
L1
115 VAC
400 Hz
1ϕ
B
A
C7
0.047
±10%
MOT
B2
RED/BLK
BLACK
RED
C4
1.5 ± 20%
H
K
B
A
VARIABLE PHASE
POWER SUPPLY
D
C
F
L
M
P2
J2
T1
BLK/WHT
RED/WHT
SYNCHRO OUTPUT
D
E
C
BLUE
BLACK
YELLOW
B1
J1
SYNCHRO
T3
RED
YELLOW
BLACK
GRAY
VARIABLE RELUCTANCE CORE
CR1
CR2
CR3
CR4
C8
0.01
±20%
C1
0.15
±20%
C2
0.15
±20%
R1
5K ± 2%
R2
5K ± 2%
Q1
Q2
R6
100
± 2%
R5
3K
±2%
R7
3K
±2%
C3
1.0 ± 20%
R3
6.8K
±2%
R4
7.5K
±2%
CR5
T2
CR6
R9
4K ± 2%
R8
5 ± 5%
R10
4K ± 2%
Q3
Q4
1
2
3
4
5
6
7
8
9
10
11
12

Figure 10.

1020

1030

Frame 7

Notice in figure 10 that 115V AC, 400 Hertz, single-phase, is applied to the power supply of the transducer. Also to the fixed phase of the transducer servomotor and synchro rotor and the signal sensing circuit (T3). The power supply furnishes DC operating voltages to the transducer amplifier. The 115V AC, 400 Hertz, single phase, is also applied to the pilot's and flight engineer's indicators.

Circle the letter of the correct answer.

1. The voltage requirement for the engine pressure ratio system is

   a. 26V AC, 400 Hertz, single-phase.
   b. 115V AC, 60 Hertz, single-phase.
   c. 115V AC, 400 Hertz, single-phase.
   d. 115V AC, 400 Hertz, three-phase.

Answers to Frame 6: 1. a 2. a 3. a 1057

Frame 8

The tape is mechanically positioned by the gear train and two tape drums. The tape threading route and the tape drums are shown in figure 11. When the gear train is moved by the servomotor, the tape drum rotates in the direction shown by the arrow on its side. The small tape take-up drum is turned at the same time in the direction shown by the arrow on its side. When the drums rotate, the tape is moved in the direction shown by the arrows near the tape. Notice in figure 11 that the face of the indicator shows the tapes for all four engines.

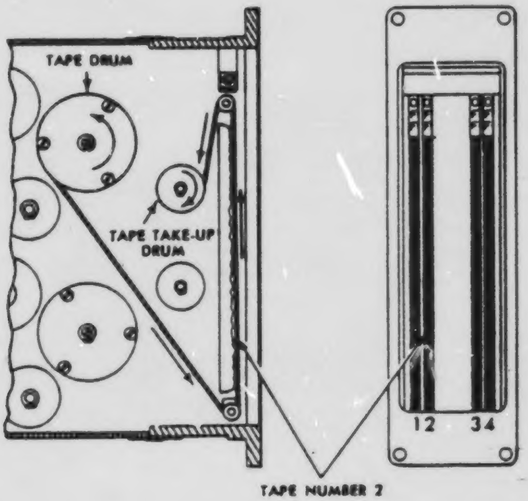


Figure 11.

Refer to figure 11 to answer the following question. Circle the letter of the correct statement.

1. The pulleys and tape threading diagram is for tape number

   a. 1.
   b. 2.
   c. 3.
   d. 4.

Answer to Frame 7: 1. c

Frame 9

There is a spiral spring located inside the tape drum. One end of the spring is locked to the tape drum shaft and the other end is locked to the tape drum housing. When the tape drum is rotated by the gear train, the tension on the spiral spring is increased. When power to the system fails, the tension of the spiral spring causes the gear train and the tape drums to rotate in the opposite direction. The tape moves opposite the direction of the arrows shown in figure 12 until the word OFF appears at the top of the indicator.

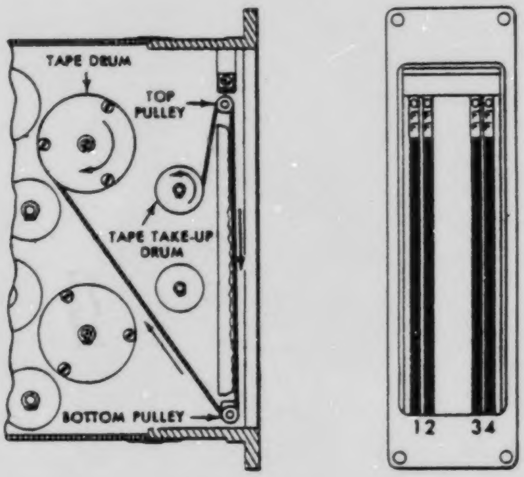


Figure 12.

Circle the letter of the correct statement.

1. The unit that returns the indicator tape to OFF due to loss of power is the

   a. spiral spring.
   b. DC motor.
   c. servomotor.
   d. gear train.

Answer to Frame 8: 1. b

Frame 10

The indicators are arranged so that when no power is applied to the system, the spiral spring moves the gear train backward, causing the word OFF to appear at the top of the indicator. At the same time, the rotor of the indicator synchro is turned a little past null.

Circle the letter of the correct statement.

1. The unit that turns the synchro rotor past null is the

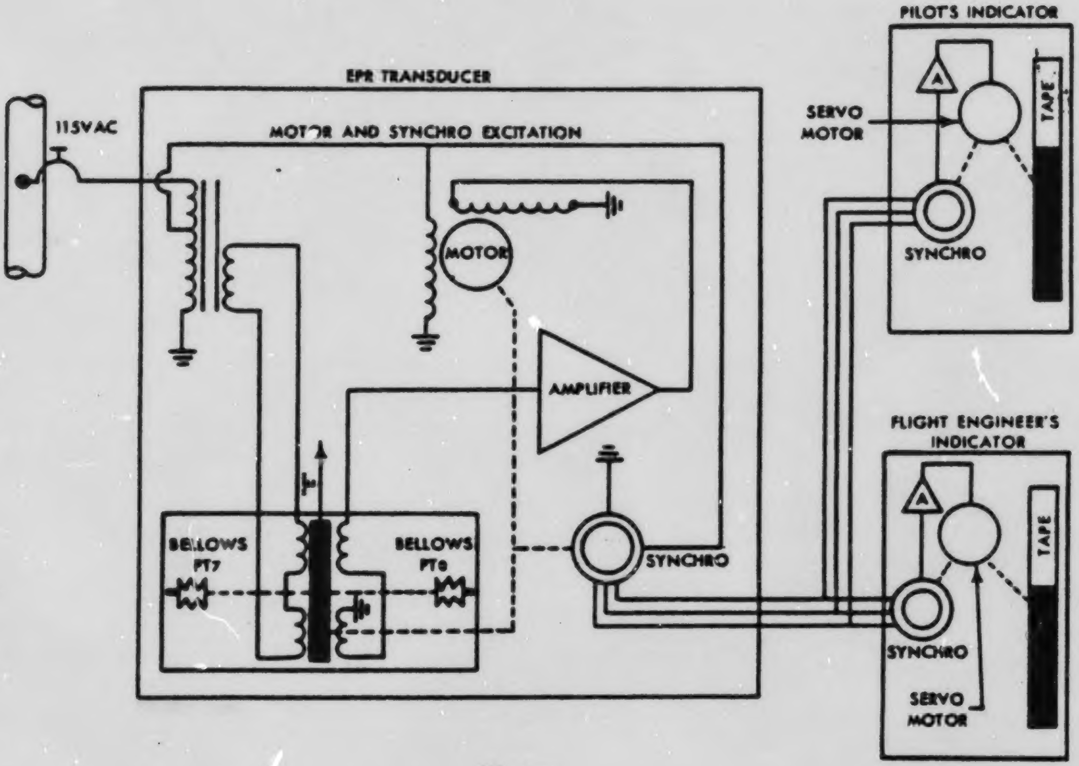
   a. servomotor.
   b. spring.
   c. amplifier.

Answer to Frame 9: 1. a

1034

Frame 11

When power is applied to the system, a voltage is induced into the stators of the synchro in the transducer. Notice in figure 13 that the stators of the synchro in the transducer are directly connected to the stators of the synchros in the pilot's and flight engineer's EPR indicators, thus forming a servoloop. From this point, the pilot's and flight engineer's systems operate identically, so you will study about just one system.


PILOT'S INDICATOR
EPR TRANSDUCER
115VAC
MOTOR AND SYNCHRO EXCITATION
SERVO MOTOR
A
TAPE
MOTOR
SYNCHRO
AMPLIFIER
FLIGHT ENGINEER'S INDICATOR
BELLOWS PT7
BELLOWS PT2
SYNCHRO
A
TAPE
SYNCHRO
SERVO MOTOR

Figure

NO RESPONSE REQUIRED

Answer to Frame 10: 1. b

1061

The voltage that is induced into the transducer synchro stators is transferred to the stators of the synchro in the indicator. Because the rotor of the indicator synchro is not at null, an error signal is induced into the rotor. The error signal from the rotor is fed to the indicator amplifier. The signal is amplified and applied to the control phase winding of the indicator servomotor. The servomotor has a rate generator attached to it, so that when the motor runs, the rate generator runs. See figure 14.

Circle the letter of the correct answer.

1. The amplified signal directly drives the

   a. servomotor.
   b. rate generator.
   c. indicator synchro.

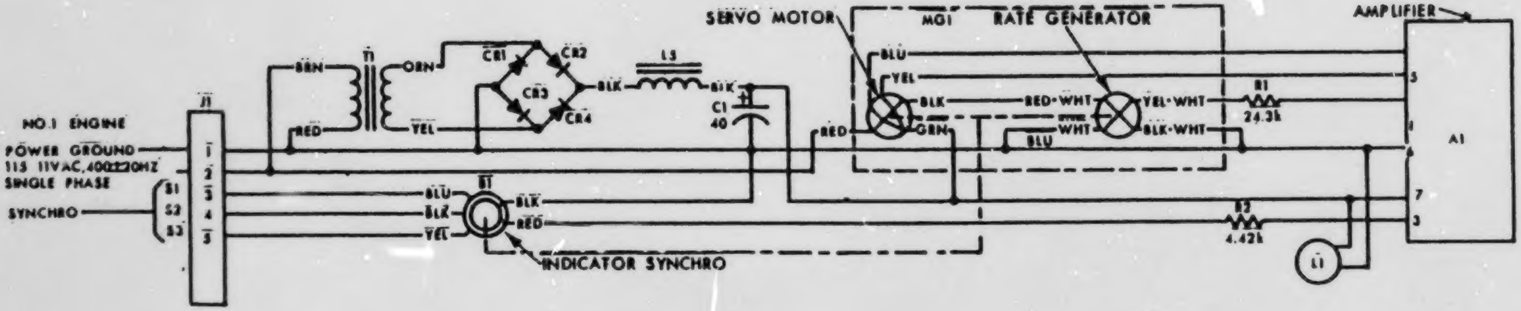

SERVO MOTOR
MG1
RATE GENERATOR
AMPLIFIER
BLU
YEL
BLK
RED-WHT
YEL-WHT
R1
24.3k
WHT
BLK-WHT
BLU
GRN
RED
BRN
T1
ORN
CR1
CR2
CR3
CR4
BLK
L3
BLK
C1
40
RED
YEL
NO.1 ENGINE
POWER GROUND
115 11VAC,400±20HZ
SINGLE PHASE
S1
S2
S3
SYNCHRO
J1
1
2
3
4
5
BLU
BLK
YEL
B1
BLK
RED
INDICATOR SYNCHRO
R2
4.42k
L1
5
1
6
7
3
A1

Figure 14.

When the control phase winding of the indicator servomotor is energized, the motor starts to drive. As the servomotor drives, the rate generator, movable tape, and the rotor of the indicator synchro are all moved by the gear train. The rotor of the indicator synchro is moved toward NULL. The servomotor continues to drive until the rotor of the indicator synchro is perpendicular to the stator's magnetic field. At this time, the indicator servomotor stops because the rotor of the indicator synchro has nulled out the error signal that was induced by the transducer synchro. The tape is moved far enough to remove the word OFF from view and the indicator is blank except for the calibrated scale. See figure 15, number 1 engine tape.

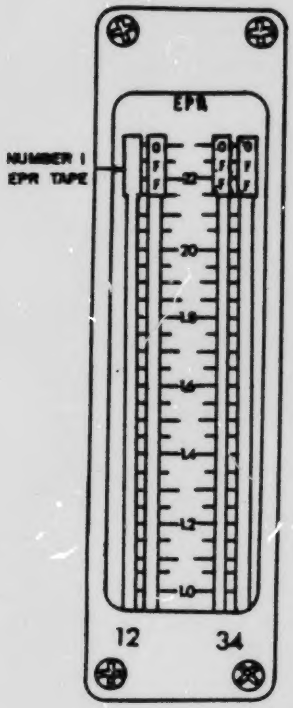


Figure 15.

Circle the letter of the correct statement.

1. The vertical scale tape is moved by the

   a. gear train.
   b. rate generator.
   c. rotor of the synchro.

Answer to Frame 12: 1. a

Frame 14

The rate generator in the EPR vertical scale indicator is driven by the servomotor. The rate generator is used as a signal damping device to prevent oscillation and overtravel of the servomotor and indicator tape during operation. To perform the damping action, the rate generator develops a voltage in opposition to the original input signal to the servoamplifier. See figure 16.

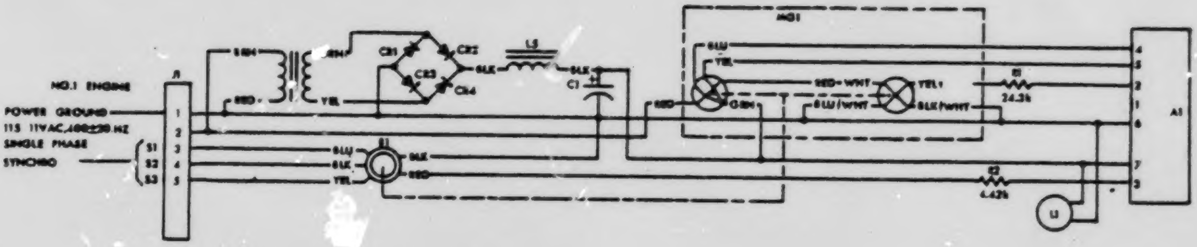

NO.1 ENGINE
POWER GROUND
115 VAC, 400±20 HZ
SINGLE PHASE
SYNCHRO
S1
S2
S3
J1
1
2
3
4
5
GRN
RED
YEL
CR1
CR2
CR3
CR4
BLK
L1
C1
BLU
BLK
YEL
RED
MG1
BLU
YEL
RED
GRN
RED-WHT
BLU/WHT
YEL
BLK/WHT
R1
24.3k
R2
4.42k
A1
4
5
2
1
6
7
3

Figure 16.

Circle the letter of the correct statement.

1. The unit that directly prevents the oscillation and overtravel of the servomotor and indicator tape during operation is the

   a. rotor.
   b. amplifier.
   c. rate generator.
   d. control transformer.

Answer to Frame 13: 1. a

As the engine is started, a pressure ratio between the engine inlet pressure and the engine exhaust pressure is sensed by the dual bellows (P_{t_0} and P_{t_7}) in the transducer. The P_{t_0} bellows is connected to the engine inlet (ram air pressure) probe. This probe is located on the top inboard side of the engine pylon as shown in figure 17. The P_{t_7} bellows is connected to the six engine exhaust gas pressure sensing probes. These probes are located around the engine discharge passage as shown in figure 18.

Circle the letters of the correct statements.

1. The P_{t_0} probe senses intake air pressure and
    a. sends an electrical signal to the P_{t_0} bellows.
    b. is connected to the P_{t_7} bellows.
    c. is connected to the P_{t_0} bellows.
    d. sends an electrical signal to the P_{t_7} bellows.
2. The P_{t_7} probe senses exhaust gas pressure and
    a. is connected to the P_{t_0} bellows.
    b. is connected to the P_{t_7} bellows.
    c. sends an electrical signal to the P_{t_0} bellows.
    d. sends an electrical signal to the P_{t_7} bellows.

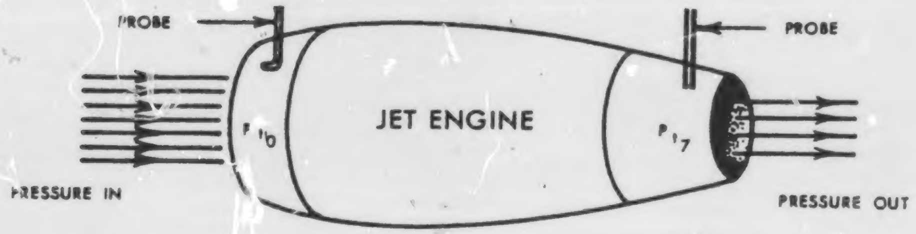


Figure 17.

Frame 15 (Continued)

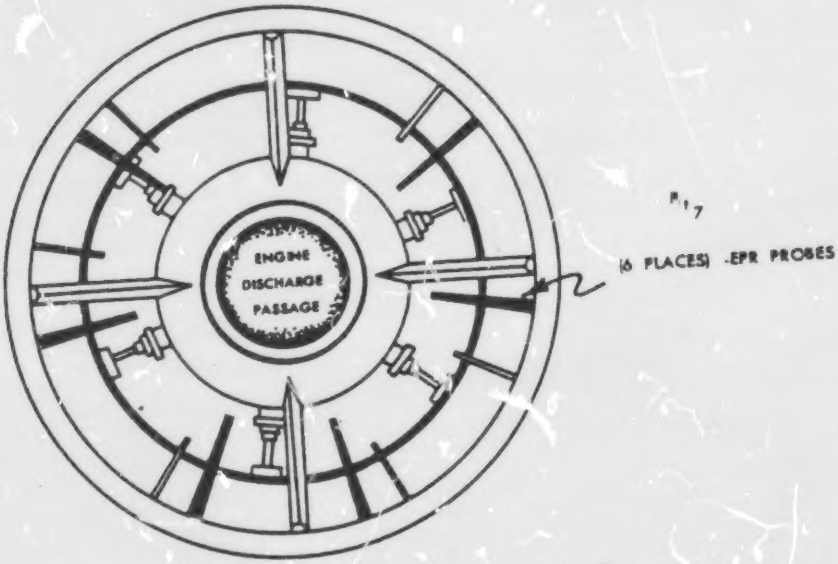

ENGINE
DISCHARGE
PASSAGE
Pt7
(6 PLACES) -EPR PROBES

Figure 18.

Answer to Frame 14: 1. c

Use figures 19 and 20 at the end of section D to answer the next FIVE frames.

The movement of the dual bellows causes the variable reluctance core of the signal-sensing unit to move up. This movement causes the inductive bridge to become unbalanced and an error signal is applied to the transducer amplifier. Here the signal is amplified and sent to the control phase of the transducer servomotor. See figure 19.

Circle the letters of the correct statements below.

1. The movement of the movable variable reluctance core in the EPR transducer unbalances the

    a. synchro.
    b. servomotor.
    c. rectifier bridge circuit.
    d. inductive bridge.

2. The error signal from the variable reluctance bridge is amplified and sent to the

    a. synchro.
    b. rectifier bridge circuit.
    c. variable phase of the servomotor.
    d. fixed phase of the servomotor.

Answers to Frame 15: 1. c 2. b

Frame 17

As the servomotor drives, a gear train positions the rotor of the transducer synchro. At the same time it moves the variable reluctance core of the signal sensor. The motor continues to drive until the variable reluctance core is moved down far enough to rebalance the inductive bridge circuit of the signal sensor. When the inductive bridge circuit is balanced, an error signal is no longer sent to the amplifier and the servomotor stops. The principle of operation of the EPR transducer is based on the use of a variable reluctance coil.

Refer to figure 20 to answer the following questions. Circle the letters of the correct statements.

1. The variable reluctance core is moved down by the

   a. synchro.
   b. bellows.
   c. servomotor.

2. The vertical scale EPR transducer uses a

   a. resistance reactance circuit.
   b. variable reluctance coil.
   c. capacitance reactance circuit.
   d. servo driven potentiometer circuit.

Answers to Frame 16: 1. d 2. c

Frame 18

At this time, the rotor of the indicator synchro is no longer null. The movement of the rotor in the transducer synchro changed the induced voltage in the stators. Since the stators of the two synchros are directly connected, this voltage change is also felt in the stators of the indicator synchros. Because of the voltage change in the stators, an error signal is induced into the rotor of the indicator synchro.

Circle the letter of the correct statement.

1. The error signal is induced into the stators of the indicator synchro through

   a. magnetic attraction.
   b. magnetic repulsion.
   c. electrical wiring.
   d. mechanical linkage.

Answers to Frame 17: 1. c 2. b

Frame 19

The signal induced into the rotor is applied to the indicator amplifier. The signal is amplified and is sent to the control phase of the servomotor. As the motor drives, the tape is positioned up scale to show the increase in EPR and the rotor of the synchro is turned toward NULL. At the same time, the rate generator is being driven by the servomotor. The rate generator develops a voltage in opposition to the original input signal to the servo-amplifier. This opposition voltage is used as a damping voltage to prevent oscillation of the servomotor and overtravel of the tape.

Circle the letter of the correct statement.

1. The rate generator is used to

   a. drive the synchro rotor.
   b. drive the servomotor.
   c. move the tape upscale.
   d. develop a damping voltage.

Answer to Frame 18: 1. c

The indicator servomotor continues to drive until the indicator synchro rotor reaches the NULL position. When the synchro rotor reaches NULL position, the error signal is NO longer applied to the servo-amplifier and the servomotor stops running. At this time, the indicator tape indicates the NEW EPR reading.

NO RESPONSE REQUIRED

Answer to Frame 19: 1. d

Frame 21

If the EPR of the engine decreases, the same sequence of events takes place. However, the phasing of ALL of the signals is opposite those for an increase in EPR. Consequently, the motor drives in the opposite direction and the spring in the EPR indicator winds the tape down scale. Therefore, we can say that the purpose of the EPR system is to measure the ratio of pressure between the engine inlet air pressure and the engine exhaust gas pressure. You should have noticed that this is the only vertical scale engine instrument system studies that did NOT use the converter.

Circle the letters of the correct answers.

1. The purpose of the engine pressure ratio system is to measure the ratio between the inlet air

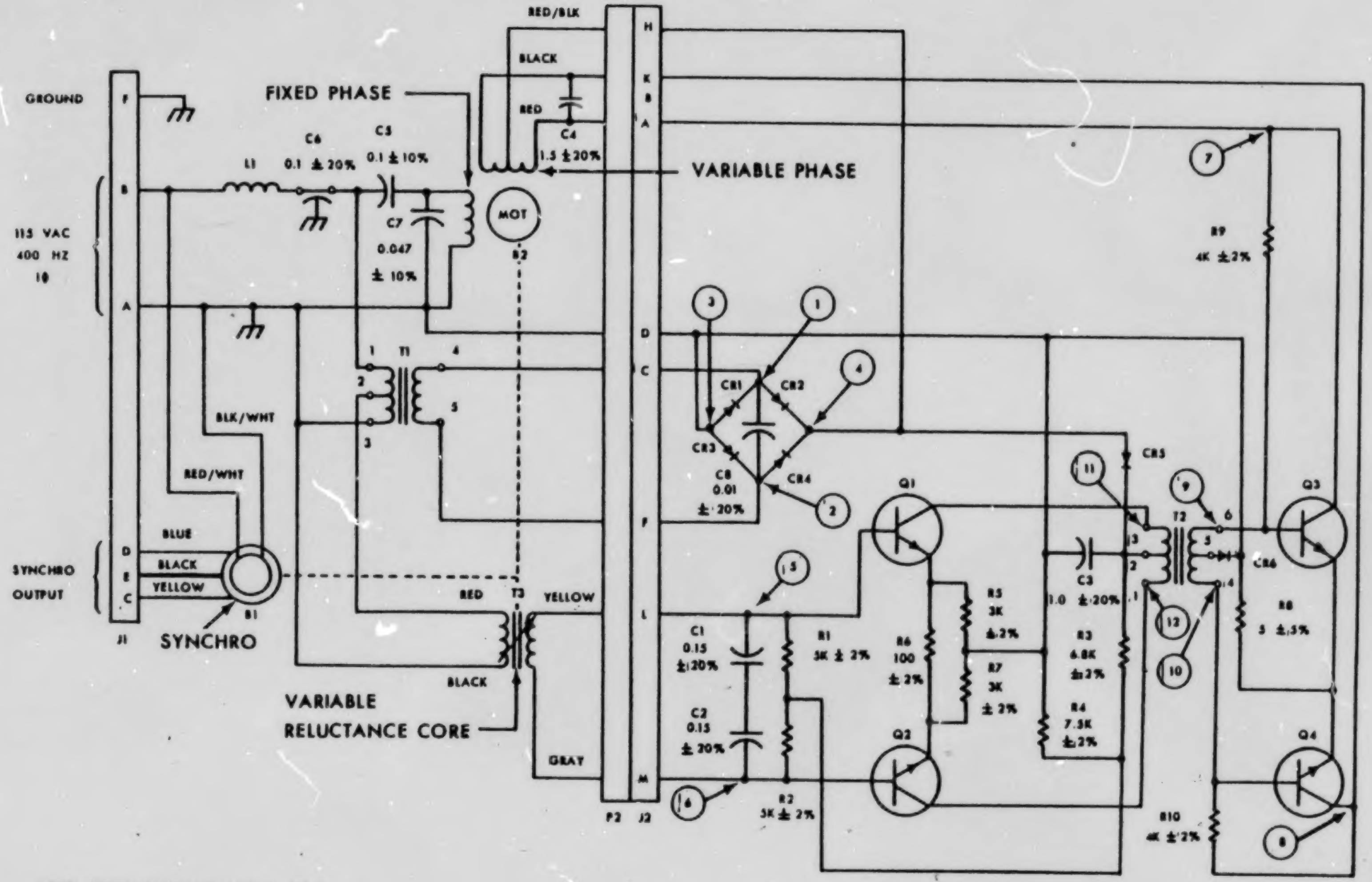
   a. temperature and exhaust gas temperature.
   b. pressure and exhaust gas temperature.
   c. pressure and exhaust gas pressure.
   d. temperature and exhaust gas pressure.

2. The vertical scale engine instrument system that does NOT use the converter is the

   a. tachometer indicator system.
   b. fuel flow indicator system.
   c. engine pressure ratio indicator system.
   d. exhaust gas temperature indicator system.

Answers to Frame 21: 1. c 2. c

Take appraisal for section D.


RED/BLK
BLACK
RED
C4
1.5 ± 20%
H
K
B
A
D
C
F
L
M
P2
J2
GROUND
F
FIXED PHASE
VARIABLE PHASE
C6
0.1 ± 20%
C5
0.1 ± 10%
L1
B
115 VAC
400 HZ
1Ø
A
C7
0.047
± 10%
MOT
B2
1
T1
4
2
5
3
BLK/WHT
RED/WHT
BLUE
SYNCHRO
OUTPUT
D
BLACK
E
YELLOW
C
B1
J1
SYNCHRO
RED
T3
YELLOW
BLACK
GRAY
VARIABLE
RELUCTANCE CORE
3
1
4
CR1
CR2
CR3
CR4
C8
0.01
± 20%
2
15
C1
0.15
± 20%
C2
0.15
± 20%
16
R1
3K ± 2%
R2
3K ± 2%
Q1
Q2
R6
100
± 2%
R5
3K
± 2%
R7
3K
± 2%
C3
1.0 ± 20%
R3
6.8K
± 2%
R4
7.5K
± 2%
CR5
11
T2
3
2
1
12
10
9
6
5
4
CR6
R8
5 ± 5%
7
R9
4K ± 2%
Q3
Q4
R10
4K ± 2%
8

NOTE: RESISTANCE VALUES ARE IN OHMS.
CAPACITANCE VALUES ARE IN MICROFARADS UNLESS
OTHERWISE SPECIFIED.

Figure 19.

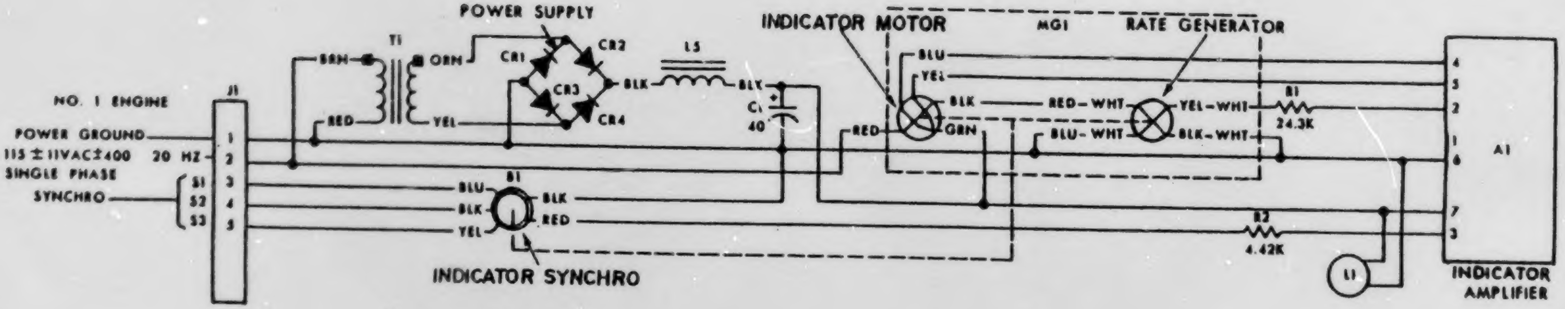

POWER SUPPLY
INDICATOR MOTOR
MG1
RATE GENERATOR
NO. 1 ENGINE
POWER GROUND
115 ± 11VAC ± 400 20 HZ
SINGLE PHASE
SYNCHRO
S1
S2
S3
J1
1
2
3
4
5
T1
BRN
RED
ORN
YEL
CR1
CR2
CR3
CR4
BLK
L5
BLK
C1
40
BLU
YEL
BLK
GRN
RED
RED-WHT
BLU-WHT
YEL-WHT
BLK-WHT
R1
24.3K
R2
4.42K
B1
BLU
BLK
YEL
BLK
RED
INDICATOR SYNCHRO
L1
4
5
2
1
6
7
3
A1
INDICATOR AMPLIFIER

Figure 20.

1049

WORKBOOK

3ABR32531-WB-209

Technical Training

Vertical Scale Engine Instruments

12 September 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.
Do Not Use on the Job.

1079

1050

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-209

INSPECTION, OPERATIONAL CHECK, TROUBLESHOOTING AND BENCH CHECK OF VERTICAL ENGINE INSTRUMENT SYSTEM

SPECIAL INSTRUCTIONS

This workbook is written in TWO sections. The first section covers the Inspection, Operational Check and Troubleshooting of the Vertical Scale Engine Instrument System. The second part covers Bench Check of the Engine Instrument System Converter.

OBJECTIVES

Given a workbook, tools, test equipment and trainer, perform an inspection and operational check of Vertical Scale Engine Instruments with an accuracy of 100% correct workbook responses.

Given a workbook, test equipment, and trainer, troubleshoot Vertical Scale Engine Instruments with an accuracy of 80% correct workbook responses.

Given a workbook, test equipment, and trainer, bench check components of Vertical Scale Engine Instruments with an accuracy of 100% correct workbook responses.

SECTION A

EQUIPMENT

	Basis of Issue
Vertical Scale Engine Instrument Trainer	1/2 students
Multimeter	1/student
Jet Cal Tester	1/2 students
Pneumatic Tester Part #268000	1/2 students
Wrench (3/8 x 9/16)	1/2 students

PROCEDURE

Remove all jewelry before inspecting, performing the operational check, and troubleshooting. Use extreme caution when using the Jet Cal Tester, as the heaters and the thermocouples get extremely hot. Be careful when removing or connecting the heater probes to the thermocouples as they are easily damaged. Do NOT damage any of the test equipment or trainer.

Supersedes 3ABR32531-WB-214, 30 April 1975; 3ABR32531-WB-214A, 3 September 1974, which may be used until existing stocks are exhausted.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC-W - 200; TTVSR - 1

1050

Part 1. VISUAL INSPECTION

1. Visually inspect the EGT indicator for the following conditions by placing a checkmark (✓) on the proper blanks.

		Satisfactory	Unsatisfactory
a.	Security of mounting.		
b.	Cracked or loose glass.		
c.	Condition of fluorescent markings.		
d.	All four OFF flags are visible.		

2. Visually inspect the Fuel Flow indicator for the following conditions.

a.	Security of mounting.		
b.	Cracked or loose glass.		
c.	Condition of fluorescent markings.		
d.	All four OFF flags are visible.		

3. Visually inspect the N-1 and N-2 Tachometer indicators for the following conditions.

		N-1	N-2	N-1	N-2
a.	Security of mounting.				
b.	Cracked or loose glass.				
c.	Condition of fluorescent markings.				
d.	All four OFF flags are visible.				

4. Visually inspect the EPR indicator for the following condition.

a.	Security of mounting.		
b.	Cracked or loose glass.		
c.	Condition of fluorescent markings.		
d.	All four OFF flags are visible.		

5. Visually inspect the circuit breakers for the following conditions.

		Satisfactory	Unsatisfactory
a.	Broken circuit breakers.		
b.	Positive push-pull action.		

6. Visually inspect the EGT, N-1 and N-2 indicators for range markings.

   a. EGT ________ __________

   b. N-1 ________ __________

   c. N-2 ________ __________

Part 2. OPERATIONAL CHECK

Note: Connect Jet Cal Tester and install heater probes on the thermocouples. Do NOT heat the thermocouples at this time.

Perform an operational check of the Vertical Scale Engine Instrument System. Place a checkmark (✓) on the proper blank.

1. Make sure all the trouble switches are to the OUT position.

2. Make sure all circuit breakers are pulled OUT.

3. Make sure the 28 VDC power switch and the 115 VAC 400 Hz power switches are to the OFF position on the AC/DC power panel.

4. Connect the trainer power cords to the 28 VDC outlet and the 115 VAC 400 Hz outlet.

5. Push the 28 VDC circuit breaker and the 115 VAC 400 Hz circuit breaker to the IN position on the main AC/DC power panel.

6. Place the 28 VDC power switch and the 115 VAC 400 Hz power switch to the ON position on the main AC/DC power panel. Raise and lock wiring diagram shelf on trainer.

   a. The 28 VDC power lamp glows ______, does not glow ________.

   b. The 115 VAC 400 Hz power lamp glows ______, does not glow ______.

7. Push all circuit breakers to the IN position.

   a. All #1 engine OFF flags are removed from view ______, are not removed from view ________.

8. Refer to the instructions in the lid of the Jet Cal Tester and heat the four thermocouples to 500 degrees Centigrade using the degrees centigrade scale on the Jet Cal Tester.

   Note: Maintain the 500 degrees Centigrade setting for operational checks and troubleshooting.

   a. The #1 engine EGT indicator indicates an increase in temperature ________, decrease in temperature ________, no change in temperature.

9. Rotate the N-1 Tachometer Generator control clockwise to read 50% rpm on the indicator.

a. The #1 engine N-1 Tachometer indicates an increase in RPM _____, decrease in RPM _____, no change in RPM _______.

10. Rotate the N-2 Tachometer Generator control clockwise to read 50% RPM on the indicator.

a. The #1 engine N-2 Tachometer indicates an increase in RPM ______, decrease in RPM ______, no change in RPM _____.

11. Advance the Fuel Flow lever to read 10,000 PPH on the indicator.

a. The #1 engine fuel flow indicator indicates an increase in fuel flow ______, decrease in fuel flow ______, no change in fuel flow _______.

12. Connect the Pneumatic Tester to P 7 port on trainer. Close all valves (clockwise) on the Pneumatic Tester. Using the pressure pump, increase pressure until the pressure indicator reads 34 psi. Open valve #4 until the Machmeter reads 1.0 Mach, then close #4 valve.

Note: Maintain 1.0 Mach for operational check and troubleshooting.

a. The #1 engine EPR indicator indicates an increase in EPR _____, decrease in EPR _____, no change in EPR ____.

Part 3. TROUBLESHOOTING

1. Using the trouble switches listed in the following chart, perform an operational check and fill in the blanks with the correct information.

Note: #1 trouble is an EXAMPLE.

2. Move #1 trouble switch to the IN position.

3. Watch ALL indicators for indication of trouble.

4. Record indication on Chart 1.

5. Place trouble switch #1 to the OUT position. Repeat procedures on trouble switches 2 thru 17.

1054

Trouble Switch #	Indication of trouble on #1 engines
1	Fuel Flow OFF flag shows.
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
17	

Chart 1

Check with instructor before removing power.

6. After recording indication for trouble switch #17, place trouble switch #17 to the OUT position.

7. Bleed the pressure OFF the pneumatic tester by opening valves 3, 4, and 5. Disconnect the hose from the transducer connection. Stow the hose in the tester. Close and latch the lid on the tester.

Note: Replace cover cap on EPR transducer connector.

8. Retard fuel flow control (throttle).

9. Turn the N-1 and N-2 tachometer control knobs fully counterclockwise.

10. Place switch S-1 on Jet Cal Tester to OFF position.

11. Disconnect Jet Cal power cable and stow in bottom of tester.

12. Disconnect heater cable from tester and junction box and stow in bottom of tester.

13. Disconnect heater probe leads from junction box.

14. Remove heater probes from thermocouples and stow in special slots in top compartment of tester. Junction box is to be stowed in this compartment.

Note: Be careful not to get burned or damage the heater probes and thermocouples.

15. Pull ALL circuit breakers and place the two trainer power switches to the OFF position.

16. Disconnect the 28 VDC and the 115 VAC 400 Hz power leads and secure on back of trainer.

17. Obtain a multimeter and leads for troubleshooting.

Note: Trouble #1 is an example of how the following Chart 2 is to be filled out. A trouble switch has to be to the IN position before you can find your trouble. When you have found your trouble, be sure to turn that switch to the OUT position before proceeding to the next trouble. Do NOT flip trouble switches ON and OFF during troubleshooting. Your multimeter should be relied on to indicate when you have found the trouble.

18. Electrical connector plugs are not disconnected on the trainer, so this is an example of CLOSED CIRCUIT troubleshooting. In most cases, an OPEN will feed back through other wires in the circuit, and a high resistance indication will be read. Proceed with your troubleshooting.

Note: You cannot check for shorts or crossed wires.

Trouble Switch #	Location of Trouble Wire Number	Kind of Trouble OPEN	High Resistance
1	1E500A20 1E500B20		✓
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
17			

Chart 2

19. Check troubles with instructor.

20. When you have finished, put your meter and leads back in the meter cabinet.

21. Turn ALL trouble switches to the OUT position and lower wiring diagram shelf on trainer.

INSTRUCTOR'S INITIALS ________

SECTION B

BENCH CHECK OF THE VERTICAL SCALE ENGINE INSTRUMENT SYSTEM CONVERTER

EQUIPMENT

	Basis of Issue
Engine Instrument System Converter	1/2 students
Test Set, Engine Instrumentation System	1/2 students
Test Set Converter	1/2 students

PROCEDURE

Note: Remove ALL jewelry before working on equipment.

Note: Before starting any test, refer to figures 1 and 2 for diagrams showing the location of the control switches for both test sets. Connect two test units and converter to the proper 115 VAC 400 Hz, 1Ø outlets. Be sure that the power plugs are properly grounded.

1. Pilot's Converter Channel Output Tests

a. Preliminary starting procedure.

(1) Set the RANGE SELECTOR SWITCH (3) of the VTVM to 300 on tester #13A3081.

(2) Set the 115-V, 400-Hz, 1Ø switch (56) of the 13A2561 system analyzer test set to the ON position.

(3) Set the 115-V, 400-Hz, 1Ø switch (34) of the 13A3081 converter output test set to the ON position.

(4) Allow a five-minute warm-up period for both test sets.

(5) Perform the test procedures listed under each module test.

b. Pilot's N1 and N2 RPM module test.

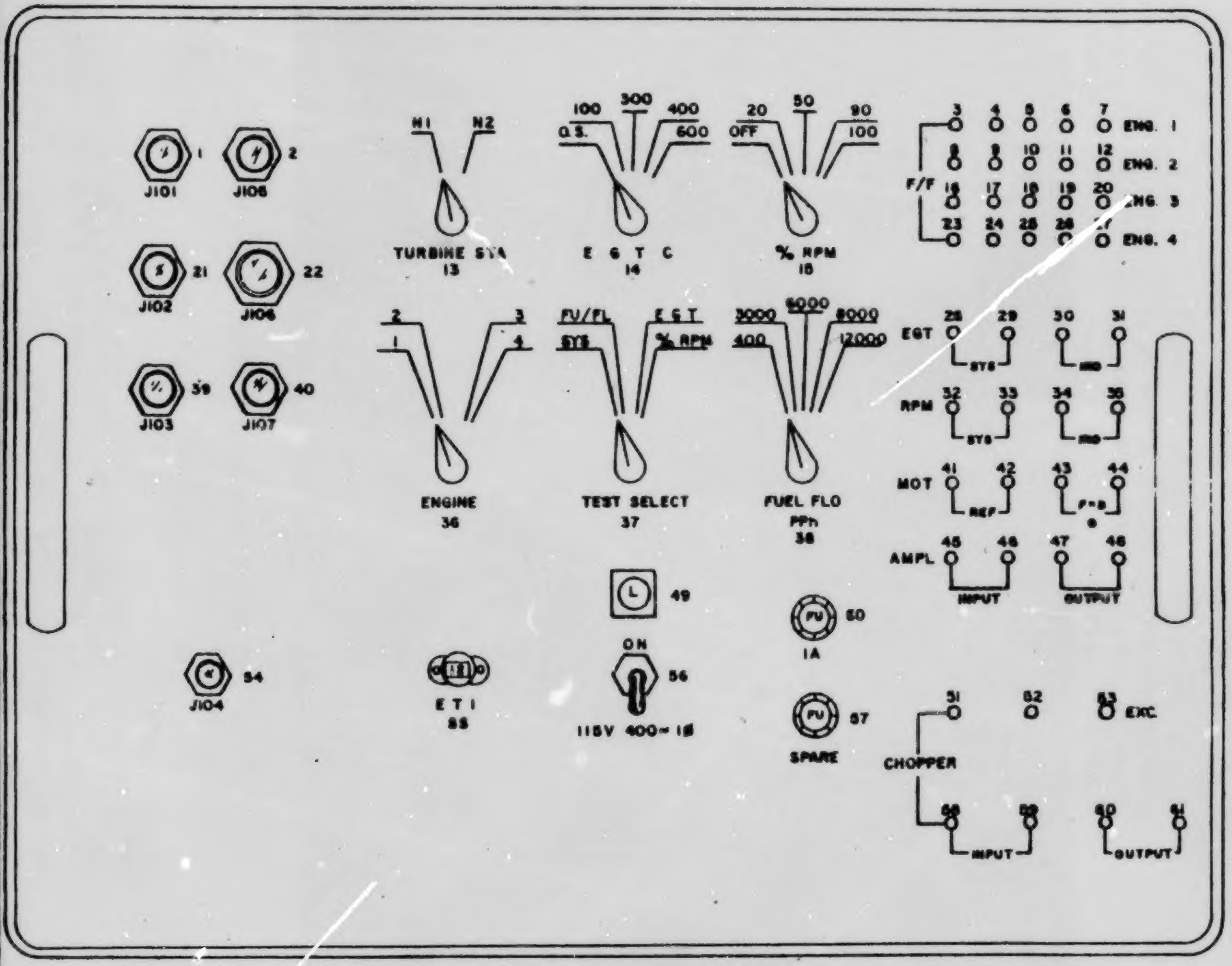
(1) N1 motor excitation test.

(a) Set the TEST SELECT switch (30) to N1-MOT EXC on tester #13A3081.

(b) Set the MOT EXC switch (38) to the ENG 1, 2, 3, and 4 positions. The VTVM meter should indicate 115 ± 11.5 volts at each engine position on tester #13A3081.

Note: When setting the MOT EXC switch, select one engine position at a time, beginning with ENG 1.

(c) Record the actual VTVM indications and the results for each engine position in the appropriate columns in table 1.


J101
1
J105
2
J102
21
J106
22
J103
39
J107
40
J104
54
N1
N2
TURBINE SYS
13
100
300
400
O.S.
600
E G T C
14
20
50
90
OFF
100
% RPM
15
2
3
1
4
ENGINE
36
FU/FL
E G T
SYS
% RPM
TEST SELECT
37
3000
6000
8000
400
12000
FUEL FLO
PPh
38
F/F
3
4
5
6
7
ENG. 1
8
9
10
11
12
ENG. 2
16
17
18
19
20
ENG. 3
23
24
25
26
27
ENG. 4
EGT
28
29
SYS
30
31
IND
RPM
32
33
SYS
34
35
IND
MOT
41
42
REF
43
44
F-B
AMPL
45
46
INPUT
47
48
OUTPUT
49
ON
56
115V 400~ 1Ø
E T I
55
FU
50
1A
FU
57
SPARE
51
52
53
EXC
CHOPPER
58
59
INPUT
60
61
OUTPUT

igure 1. Bendix Engine Instrument System Analyzer (Type 13A2561) Control Location Diagram.

1098

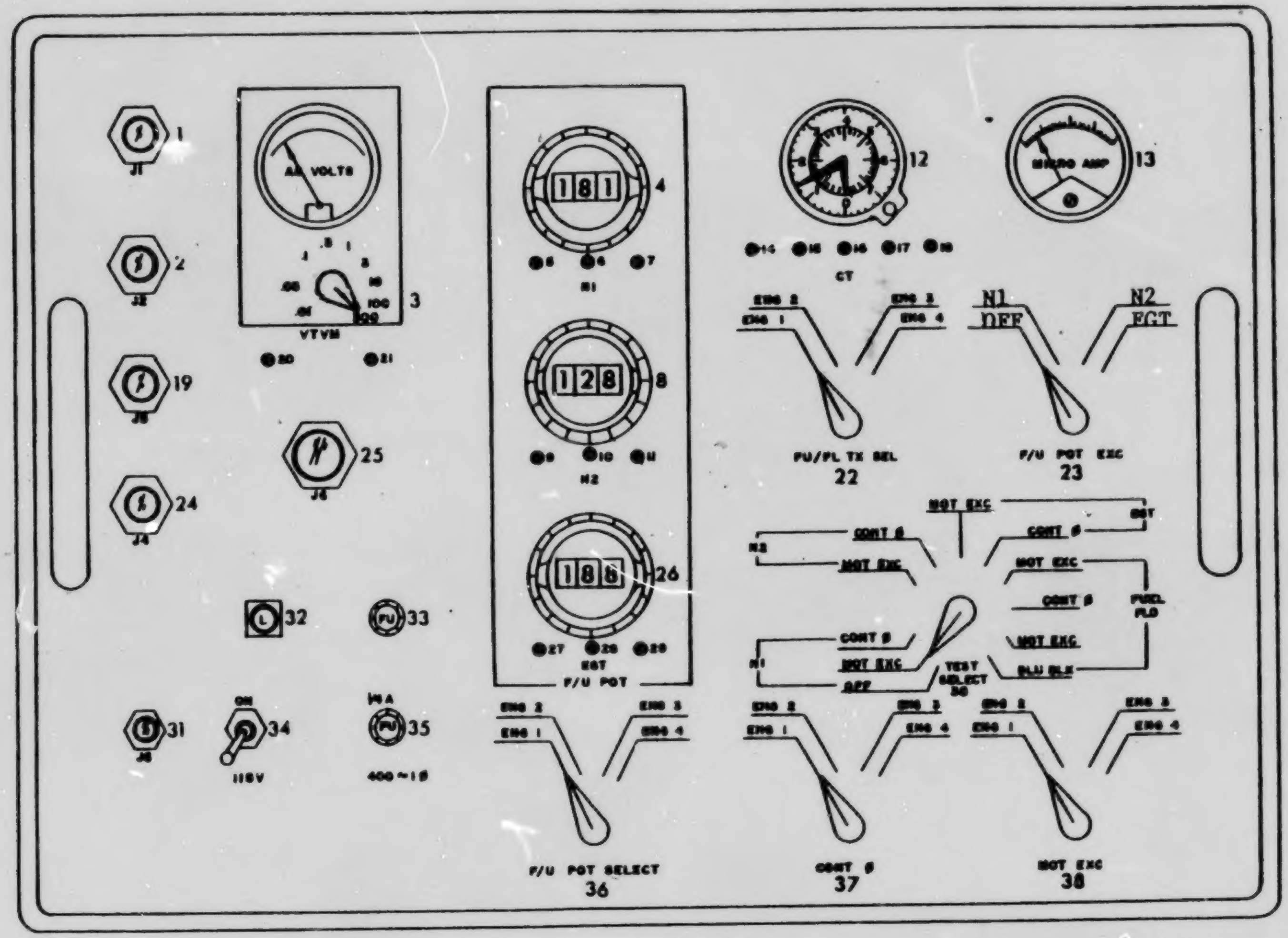

1
J1
2
J2
19
J5
24
J4
AC VOLTS
VTVM
3
25
J6
32
33
34
ON
115V
35
400~1∅
31
J6
181
4
5
6
7
N1
128
8
9
10
11
N2
188
26
27
28
29
EGT
F/U POT
12
14
15
16
17
18
CT
MICRO AMP
13
ENG 2
ENG 1
ENG 3
ENG 4
PU/PL TX SEL
22
N1
OFF
N2
EGT
F/U POT EXC
23
MOT EXC
CONT ∅
N2
MOT EXC
EGT
CONT ∅
MOT EXC
CONT ∅
FUEL FLO
CONT ∅
N1
MOT EXC
OFF
TEST SELECT
30
MOT EXC
BLU BLK
ENG 2
ENG 1
ENG 3
ENG 4
F/U POT SELECT
36
ENG 2
ENG 1
ENG 3
ENG 4
CONT ∅
37
ENG 2
ENG 1
ENG 3
ENG 4
MOT EXC
38

Figure 2. Bendix Engine Instrument System Converter Output Tester (Type 13A3081) Control Location Diagram.

Eng Position MOT EXC SW 38	Required VTVM Indications & Tolerances	Actual VTVM Indications		Results (S or U)	
		N1	N2	N1	N2
ENG 1	115 ± 11.5V				
ENG 2	115 ± 11.5V				
ENG 3	115 ± 11.5V				
ENG 4	115 ± 11.5V				

Table 1. Pilot's N1 and N2 Motor Excitation Tests.

(2) N2 motor excitation test.

(a) Follow the same procedures as for the N1 motor excitation test except set the TEST SELECT switch (30) to N2-MOT EXC on tester #13A3081.

(b) Record the actual VTVM indications and the results for each engine position in the appropriate columns in Table 1.

(3) Shutdown procedure for percent RPM motor excitation tests.

(a) Leave the 115-V, 400-Hz, 1Ø switches in the ON position on both test sets. Leave the VTVM switch to the 300 position.

(b) Set all other control switches to the extreme counterclockwise position on both test sets.

(4) N1 control phase test.

(a) Set the TURBINE STATION switch (13) to the N1 position on the 13A2561 test set.

(b) Set the following switches of the 13A3081 test set to the positions indicated.

SWITCH	POSITION
TEST SELECT (30)	N1-CONT Ø
F/U Pot SELECT (36)	ENG 1, 2, 3 or 4
CONT Ø (37)	ENG 1, 2, 3 or 4
MOT EXC (38)	ENG 1, 2, 3 or 4

Note: When setting control switches 36, 37, and 38, select one engine position at a time, beginning with the ENG 1 position.

(c) Set the % RPM switch (15) of the 13A2561 test set to the positions specified in Table 2.

AMPL	Test Point % RPM SW 15	Required F/U POT Cont Ratio Ind		Actual F/U POT Control Ratio Indication				Results (S or U)			
		Min	Max	1	2	3	4	1	2	3	4
N1 RATIO	.20	.181	.190								
	50	.451	.460								
	90	.812	.818								
	100	.902	.908								
N2 RATIO	20	.181	.190								
	50	.451	.460								
	90	.812	.818								
	100	.902	.908								

Table 2. Pilot's N1 and N2 Control Phase Test.

(d) Adjust F/U POT-N1 control (4) of the 13A3081 test set until a minimum indication is obtained on the VTVM meter. The resistance ratio indicated by F/U POT-N1 control (4) should be as specified in Table 2 for each engine position.

(e) Record the F/U POT-N1 control (4) actual indications and the results in the appropriate columns in Table 2.

(5) N2 control phase test.

(a) Follow the same procedures as for the N1 control phase test except for the following:

1. Set the TURBINE STATION switch (13) of the 13A2561 test set to position N2.

2. Set the TEST SELECT switch (30) of the 13A3081 test set to the N2-CONT Ø position.

3. Adjust F/U POT-N2 control (8) of the 13A3081 test set until a minimum indication is obtained on the VTVM meter (3). The resistance ratio indicated by F/U POT-N2 control (8) should be as specified in Table 2 for each engine position.

(b) Record the F/U POT-N2 control (8) actual indications and the results in the appropriate columns in Table 2.

(6) Shutdown procedure for percent RPM control phase test.

(a) Leave both 115-V, 400-Hz 1Ø switches in the ON position. Leave the VTVM switch in the 300 position.

(b) Set all other control switches to the extreme counterclockwise position on both test sets.

(c) Set all F/U POT controls counterclockwise to indicate .000 on tester #13A3081.

c. Pilot's exhaust gas temperature module test.

(1) Motor excitation test (EGT).

(a) Set the TEST SELECT switch (30) to the EGT-MOT EXC position on tester #13A3081.

(b) Set the MOT EXC switch (38) to the ENG 1, 2, 3, and 4 positions. The VTVM meter should indicate 115 ± 11.5 volts at each engine position on tester #13A3081.

(c) Record the actual VTVM indications and the results for each engine position in the appropriate columns in Table 3.

Engine Position MOT EXC SW 38	Required VTVM Indications and Tolerances	Actual VTVM Indications	Results (S or U)
ENG 1	115 ± 11.5V		
ENG 2	115 ± 11.5V		
ENG 3	115 ± 11.5V		
ENG 4	115 ± 11.5V		

Table 3. Pilot's EGT Motor Excitation Test.

(2) Shutdown procedure for EGT motor excitation tests.

(a) Leave both 115-V, 400-Hz 1Ø switches in the ON position. Leave the VTVM switch in the 300 position.

(b) Set all other control switches to the extreme counterclockwise position on both test sets.

(3) Control phase test (EGT).

(a) Set the following switches of the 13A3081 test set to the positions indicated.

SWITCH	POSITION
TEST SELECT 30	EGT-CONT Ø
F/U POT SELECT (36)	ENG 1, 2, 3 or 4
CONT Ø (37)	ENG 1, 2, 3 or 4
MOT EXC (38)	ENG 1, 2, 3 or 4

Note: When setting control switches 36, 37, and 38, select one engine position at a time beginning with the ENG 1 position.

(b) Set the EGT °C switch (14) of the 13A2561 test set to the positions specified in Table 4.

Test Point EGI °C SW 14	Required F/U POT Control (26) Ratio Indication		Actual F/U POT Control (26) Ratio Indications				Results (S or U)			
	Min	Max	1	2	3	4	1	2	3	4
100°C	.188	.200								
300°C	.429	.436								
400°C	.550	.557								
600°C	.784	.790								

Table 4. Pilot's Exhaust Gas Temperature Control Phase Test.

(c) Set the ENGINE switch (36) of the 13A2561 test set to the engine channel under test.

(d) Adjust the F/U POT-EGT control (26) of the 13A3081 test set until a minimum indication is obtained on the ratio indicated by the F/U POT-EGT control (26) should be as specified in Table 4.

(e) Record the F/U POT-EGT control (26) actual indications and the results in the appropriate columns in Table 4.

(4) Shutdown procedure for exhaust gas temperature control phase tests.

(a) Leave both 115-V, 400-Hz 1Ø switches in the ON position. Leave the VTVM switch in the 300 position.

(b) Set all other control switches to the extreme counterclockwise positions on both test sets.

(c) Set all F/U POT controls counterclockwise to indicate .000 on the #13A3081 tester.

d. Pilot's fuel flow module test.

(1) Motor excitation tests (Fuel Flow).

(a) Set the TEST SELECT switch (30) to the FUEL FLO-MOT EXC position.

(b) Set the MOT EXC switch (38) to the ENG 1, 2, 3, and 4 positions. The VTVM meter should indicate 115 ± 11.5 volts at each engine position on tester #13A3081.

(c) Record the actual VTVM indications and the results for each engine position in the appropriate columns in Table 5.

Engine Position MOT EXC SW 38	Required VTVM Indications and Tolerances	Actual VTVM Indications	Results (S or U)
ENG 1	115 ± 11.5V		
ENG 2	115 ± 11.5V		
ENG 3	115 ± 11.5V		
ENG 4	115 ± 11.5V		

Table 5. Pilot's Fuel Flow Motor Excitation Tests.

(2) Shutdown procedure for fuel flow motor excitation tests.

(a) Leave both 115-V, 400-Hz 1Ø switches in the ON position. Leave the VTVM switch in the 300 position.

(b) Set all other control switches to the extreme counterclockwise position on both test sets.

(3) Control phase tests (Fuel Flow).

(a) Set the following switches of the 13A3081 test set to the positions indicated.

SWITCH	POSITION
TEST SELECT (30)	FUEL FLO-CONT Ø
CONT Ø (37)	ENG 1, 3, 3 or 4
MOT EXC (38)	ENG 1, 2, 3 or 4
Fuel flow test selector switch (#22) to	ENG 1, 2, 3 or 4

Note: When setting control switches 22, 37, and 38 select one engine position at a time beginning with the ENG 1 position.

(b) Set the FUEL FLOW PPH switch (38) of the 13A2561 test set to the positions specified in Table 6.

Test Points FUEL FLO PPH SW 38	Required CT 12 Indications in Degrees	CT (12) Tolerance in Degrees	Actual CT (12) Indications in Degrees				Results (S or U)			
			1	2	3	4	1	2	3	4
400	76.8°	± 0.2°								
3000	56.0°	± 0.2°								
6000	32.0°	± 0.2°								
8000	16.0°	± 0.8°								
12000	344.0°	± 0.8°								

Table 6. Pilot's Fuel Flow Control Phase Tests.

(c) Adjust the CT control (12) of the 13A3081 test set until a minimum indication is obtained on the VTVM meter. The angle indicated in degrees on the CT indicator (12) should be as specified in Table 6.

(d) Record the actual CT (12) indications in degrees and the results for each engine position in Table 6.

e. Final shutdown procedures of the pilot's converter channel output test.

(1) Set the 115-V, 400-Hz 1Ø switches to the OFF positions on both test sets. Leave the VTVM switch in the 300 position.

(2) Set all control switches to the extreme counterclockwise positions on both test sets.

(3) Set CT control clockwise to indicate 0° on tester #13A3081.

(4) Disconnect all power cables from the power source for the converter, and both test sets.

CAUTION: THE CABLES ARE VERY DELICATE AND SHOULD BE HANDLED WITH EXTREME CARE.

INSTRUCTOR'S INITIALS __________

PROGRAMMED TEXT
3ABR32531-PT-301
3ABR32632B-PT-401

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

PITOT-STATIC SYSTEM

5 June 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

1067

FOREWORD

This programmed text was developed for use in Courses 3ABR32531, Avionics Instrument Systems Specialist and 3ABR32632B, Integrated Avionic Systems Specialist. This material has been validated by at least 20 students from the subject courses with at least 90% of the students achieving the stated objectives. The average time for completing this programmed text is 5 hours and 50 minutes.

OBJECTIVE

Without references identify facts pertaining to the purpose, operation, and/or characteristics of the basic pitot-static system and test equipment.

INSTRUCTIONS

There are two parts to this text. Complete part I and then ask your instructor for further instructions before completing part II.

The text is presented in numbered frames arranged in a learning sequence. You are required to read the information in each frame and respond to the questions on the material presented. DO NOT WRITE IN THIS BOOK. Use the response sheet to record your answers. You may check your response by looking for the correct answer at the beginning of the next frame, bottom of the page. If you selected the correct response, you may continue to the next frame. If your response was incorrect, go back and review the material. If you need assistance, ask your instructor to help you. DO NOT RUSH.

Supersedes 3ABR32531-PT-301, 3ABR32632B-PT-401, 25 February 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
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1098

Part I

Section A

PITOT-STATIC SYSTEM

Frame 1

The pitot-static system uses the air (atmosphere) around the aircraft for operation. Every aircraft from the most complex jet to the smallest reconnaisance plane has a pitot-static system. Pitot is pronounced pea-toe. The pressures supplied by the system operate the aircraft's airspeed indicators, machmeter, altimeter, vertical velocity indicator (rate of climb) and supplies pressures to other systems such as: autopilot, flight control, landing gear, etc. You will be responsible for the maintenance, troubleshooting and repair of the pitot-static system and the flight instruments operated by it. Later in the course you will learn about the flight instruments that you are responsible for maintaining.

The purpose of the pitot-static system is to sense both pitot and static pressures and transmit these pressures to the various instruments and systems located on the aircraft.

Check (✓) the statement or statements below that describe the purpose of the pitot-static system.

_____a. Measures pitot and static pressures.

_____b. Senses both pitot and static pressures.

_____c. Used to indicate the aircraft's airspeed, Mach number, and altitude.

_____d. Transmits both pitot and static pressures to various flight instruments and systems located on the aircraft.

Frame 2

Before going further into the pitot-static system, let's define the air pressures that are being used; first is static pressure.

The word "static" means "still and undisturbed." Therefore, static pressure is the pressure of the still and undisturbed air around the aircraft. Static pressure is the name or term that aircraft technicians use instead of atmospheric pressure. When the pitot-static system senses static pressure, it is sensing the air or air density that surrounds the aircraft. Another way to put it is, the still and undisturbed air about the aircraft. P_s is the symbol for static pressure.

Check the correct response(s) below.

Static pressure is

_____a. atmospheric pressure.

_____b. ram air pressure.

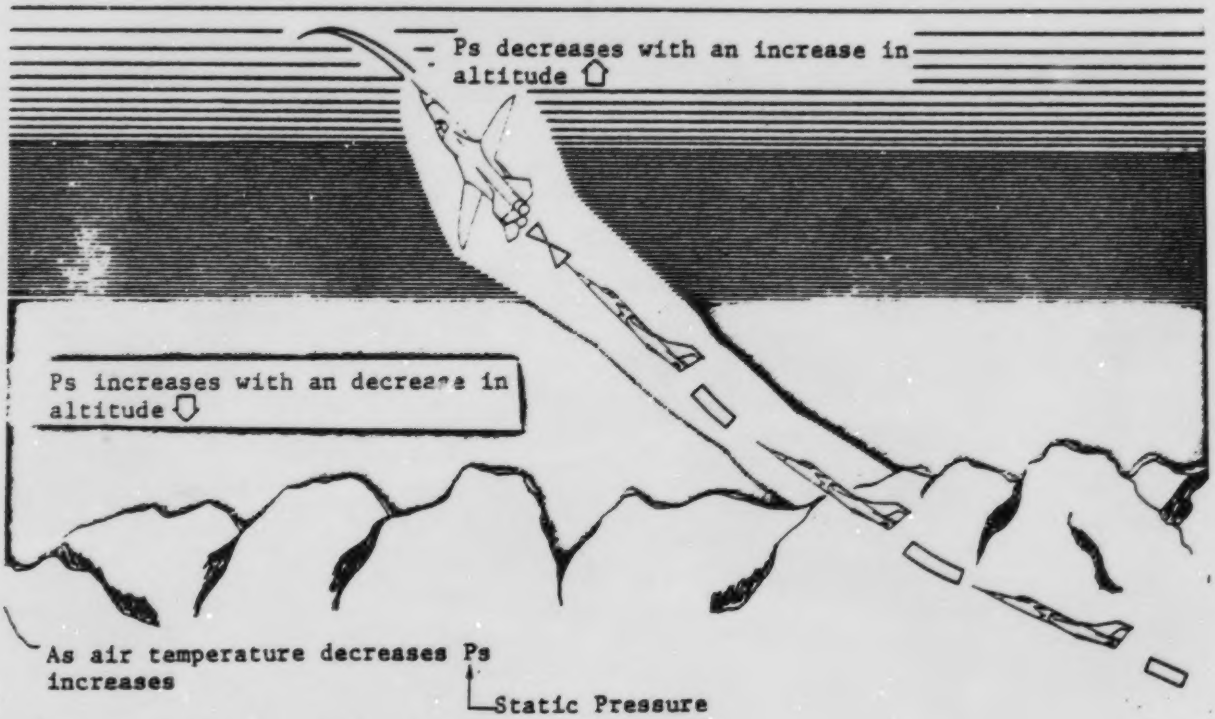
_____c. the still and undisturbed air.

_____d. P_s.

Answers to Frame 1: __✓__b. __✓__d.

Frame 3

The air around the earth can be considered as an ocean of air. This ocean of air extends upward with the static pressure decreasing with an increase in height. Like an ocean of water, the air ocean has both depth and weight. Static pressure is the greatest at the bottom of the air ocean or at the earth's surface. At sea level the normal atmospheric (air) pressure is 14.7 pounds per square inch (14.7 psi), whereas at 100,000 feet the pressure is 0.147 psi. Pressure and altitude are inversely proportional; therefore, an increase in altitude causes a decrease in static pressure. Thus we have a means of measuring the altitude at which the aircraft is flying. Also, at any given altitude a decrease in temperature will cause an increase in air density, thereby causing an increase in static pressure.


Ps decreases with an increase in altitude ⇧
Ps increases with an decrease in altitude ⇩
As air temperature decreases Ps increases
Static Pressure

Fill in the blanks on the following statements.

a. Static pressure at sea level is ______________________.

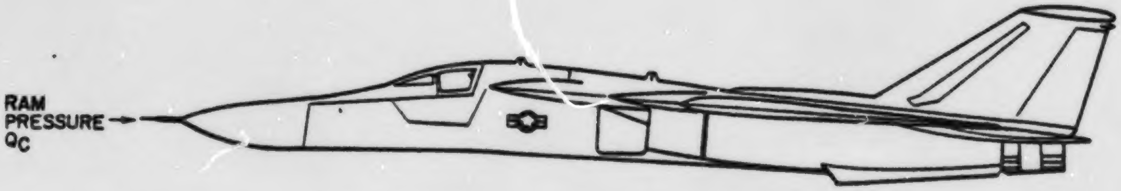
b. Static pressure increases with a _____________ in altitude.

c. Static pressure decreases as temperature ____________.

Answers to Frame 2: __✓__a. __✓__c. __✓__d.

Frame 4

Impact pressure, also known as ram pressure, is another pressure sensed by the pitot-static system. It is the air pressure that strikes the pitot tube as the result of the forward motion of the aircraft. Impact pressure is used to measure airspeed. Q_c is the symbol for impact pressure.



Check the correct response(s) below.

_____a. Static pressure is known as ram pressure.

_____b. Impact pressure is due to the forward motion of the aircraft.

_____c. Impact pressure is used to measure airspeed.

Answers to Frame 3: a. 14.7 b. decrease c. increases

1072

Pitot pressure (Pt) equals impact pressure (Qc) plus static pressure (Psi). Pitot pressure is sometimes referred to as total pressure. For example, if we had 15 psi of impact pressure and 10 psi of static pressure, the pitot or total pressure would be 25 psi. Example pertains to one altitude only.

What is pitot pressure?

_____a. The difference between impact and static pressure.

_____b. Impact pressure minus static pressure.

_____c. Total pressure plus static pressure.

_____d. Impact pressure plus static pressure.

Answers to Frame 4: __✓__b. __✓__c.

1103

Frame 6

Let's briefly review the material covered to this point. You have learned what pitot and static pressures are and how altitude affects these pressures; also that the pitot-static system operates the aircraft's speed and altitude indicators. Circle the letter of the correct answer in each of the following review questions, then proceed to frame 6.

1. The definition of pitot pressure is the

   a. vacuum pressure around the aircraft.

   b. air moving around the aircraft causing lift.

   c. still and undisturbed air around the aircraft.

   d. impact pressure plus static pressure.

2. In a column of air extending upward from the earth's surface, pressure is

   a. least at a low altitude.

   b. greatest at a low altitude.

   c. dependent only on temperature.

   d. constant throughout the column.

3. The definition of static pressure is

   a. the pressure of the moving air around the aircraft.

   b. vacuum pressure around the aircraft.

   c. the pressure of the still and undisturbed air around the aircraft.

   d. impact pressure caused by the aircraft flying forward.

4. When the aircraft slows down and remains at the same altitude, pitot pressure will

   a. increase.

   b. decrease.

   c. not change.

   d. not be affected by the change in speed.

5. An aircraft flying to a higher altitude will

   a. cause an increase in temperature.

   b. encounter a decrease in static pressure.

   c. encounter an increase in static pressure.

   d. not be affected by temperature or static pressure.

6. Static pressure would increase if the aircraft

   a. went faster.

   b. went slower.

   c. descended to a lower altitude.

   d. ascended to a higher altitude.

7. If the aircraft flies at the same speed and goes up to a higher altitude, pitot pressure will

   a. increase.

   b. decrease.

   c. not change.

   d. change into static pressure.

Answer to Frame 5: __✓__d.

Frame 7

In the next several frames you will learn about the component parts of the pitot-static system. You will learn how pitot and static pressures are sensed and transmitted to the instruments operated by these pressures. The pitot tube is a pitot pressure sensor. To properly sense pitot pressure, it must be mounted parallel with the longitudinal axis of the aircraft. Pitot pressure (impact plus static pressures) enters the pitot tube through a 1/4 inch opening located at the front of the tube. Location of the tube is not the same on all aircraft. Some aircraft have the pitot tube located on a boom in front of the aircraft's nose, others have the tube located on the wing tip or vertical stabilizer. The location of the pitot tube is not as important as the fact that, "it must be mounted parallel to the longitudinal axis of the aircraft and at a point where the air is not disturbed by the aircraft's forward movement through the atmosphere."

Check (✓) the statements that describe the location and mounting of the pitot tube.

_____a. The only place a pitot tube can be located on an aircraft is in front of the nose.

_____b. The pitot tube must be mounted parallel to the longitudinal axis of the aircraft.

_____c. The pitot tube must be located where the air is not disturbed.

Answers to Frame 6:

1. d 2. b 3. c 4. b 5. b 6. c 7. b

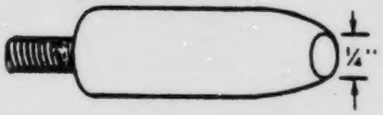
Remember, all pitot tubes are not located at the same place on aircraft. Also, they are not all the same size or shape. The inner construction of all pitot tubes is basically the same. Study the illustration below. The main parts that make up a pitot tube are:

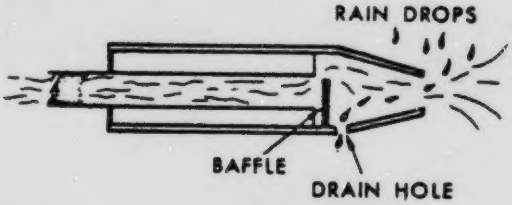
a. baffle plate which prevents water and dirt from entering the pitot-static system.

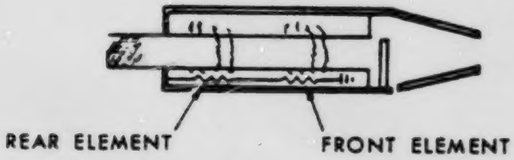
b. drain hole which allows water to drain from pitot tube.

c. 1/4" opening on the end which allows pitot pressure to enter tube.

d. two heaters or heating elements which are used to prevent icing of the pitot tube.







Using the above illustration, match the components listed below to their function.

_____1.	pitot tube	a.	senses pitot pressure
_____2.	baffle	b.	Prevents water and dirt from entering the pitot-static system
_____3.	drain hole	c.	used as the method to prevent icing of the pitot tube
_____4.	pitot heaters	d.	allows water to drain from pitot tube

Answers to Frame 7:

__✓__b. __✓__c.

1077

Frame 9

Every pitot tube has a pitot heater. The power switch for the pitot heater is located inside the cockpit within easy reach of the pilot or may be actuated automatically by the weight being removed off of the landing gear. Caution should be taken when the aircraft is on jacks to insure the pitot heater circuit breakers are pulled to prevent the heaters from being turned on by the weight being off of the landing gear. The pitot heater will burn out if it is operated on the ground for more than 30 seconds. Ground operation of the heaters causes pitot tubes to get very hot, so do not touch them immediately after operation or you will receive a severe burn.

No response required.

Answers to Frame 8:

__a__1. __b__2. __d__3. __c__4.

1108

When the aircraft is parked on the ground, a canvas pitot cover with a red streamer (flag) is put on the pitot tube. Bugs, dust and rain are kept out of the pitot tube by the canvas cover. The pitot tube cannot sense pitot pressure with the pitot cover installed. The purpose of the red streamer is to remind the crew chief to remove the pitot tube cover before takeoff.

Mark the following statements true (T) or false (F).

a. _____ The pitot cover prevents bugs, dust and rain from entering the pitot tube when the aircraft is parked.

b._____ The red streamer is a warning flag to remind the crew chief to remove the pitot cover before takeoff.

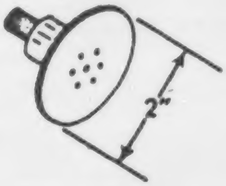
Answers to Frame 9:

No response required.

1079

Frame 11

Now that you know about the pitot pressure sensing element (pitot tube), we will discuss the static pressure sensor. The static flush plate, shown below, senses static pressure for those aircraft that do not use the type of pitot-static tube shown earlier in this text.



Static pressure enters the pitot-static system through a number of holes in the flush plate. The location of the static sensor is extremely important. To function properly, the static flush plates must be located at a particular place on the aircraft's fuselage. To determine the location of the static ports, a model of the aircraft is tested in a wind tunnel. The static flush plate must be located on the fuselage in an area of least air turbulence. This is the purpose of the wind tunnel test.

Fill in the blanks in the following statements.

a. The ____________ ________________ plate is the static pressure sensor.

b. Static pressure enters the pitot-static system through a ____________________ of ______________________ in the static flush plate.

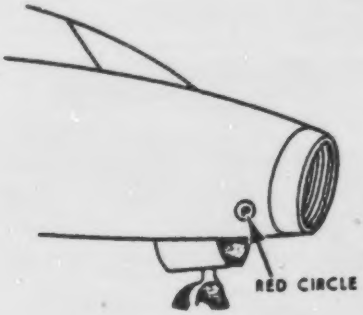
c. The location of the static flush plate is determined by a ________________ __________________ test.

Answers to Frame 10:

a. T b. T

1110

For easy location of the static flush plate, a red circle is painted around it. (Refer to illustration).



The red circle around the static flush plate warns painters or mechanics not to cover it with either paint or tape.

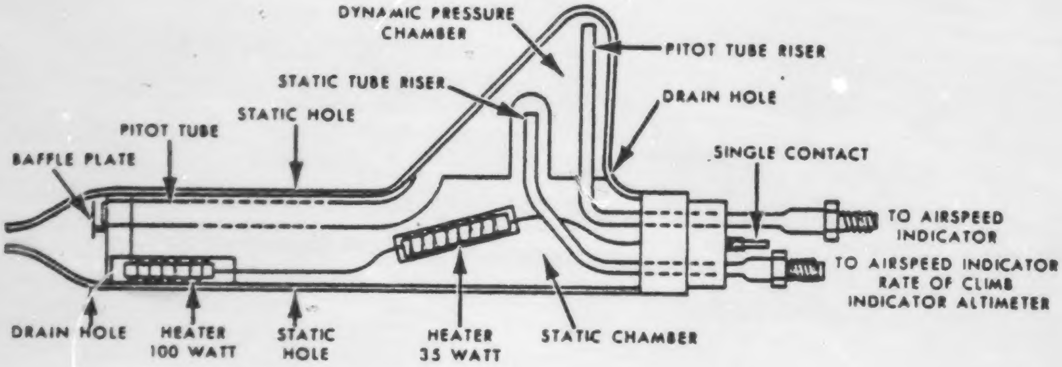
No response required.

Answers to Frame 11:

a. static flush b. number of holes c. wind tunnel

Frame 13

During the wind tunnel test of the F-100 ----- guess what? ----- They found air turbulence on all areas of the fuselage. For this reason, static flush plates (static ports) could not be mounted on the fuselage. For those aircraft (which include most modern jets) that have turbulent air everywhere on the fuselage, the static holes are located on the pitot tube. This type tube is shown below.


DYNAMIC PRESSURE CHAMBER
PITOT TUBE RISER
STATIC TUBE RISER
DRAIN HOLE
STATIC HOLE
PITOT TUBE
BAFFLE PLATE
SINGLE CONTACT
TO AIRSPEED INDICATOR
TO AIRSPEED INDICATOR RATE OF CLIMB INDICATOR ALTIMETER
DRAIN HOLE
HEATER 100 WATT
STATIC HOLE
HEATER 35 WATT
STATIC CHAMBER

A tube that senses both pitot and static pressure is called a pitot-static tube. The pitot-static tube is the same as the pitot tube, except it has static holes on the top and bottom of the tube. Pitot pressure enters the tube through the 1/4 inch hole in front, and static pressure enters through the static holes on the top and bottom of the tube.

Check (✓) the following statements that are true.

_____a. All aircraft have some point on their fuselage that has no turbulent air.

_____b. A pitot tube that senses both pitot and static pressure is called a pitot-static tube.

_____c. The pitot-static tube has a 1/4 inch hole in the end to sense pitot pressure and a number of holes on the top and bottom to sense static pressure.

Answer to Frame 12:

No response required.

Frame 14

Up to this point you have learned about pressures and pressure sensors. Later you are going to learn about the indicators that are operated with pressure. Now we are going to learn how the pressures are transmitted from the sensors to the indicators. These pressures are transmitted through the pitot-static system lines. There are two types of lines used; rigid tubing and flexible pressure hose.

No response required.

Answers to Frame 13:

✓ b. ✓ c.

Frame 15

Rigid tubing is used where there is low vibration. When installing the rigid tubing, it must be torqued to the value specified in TO. Note: Always check the TO for exact torque values! Rigid tubing is used to transmit both pitot and static pressure.

Check (✓) the following true statements.

_____a. Rigid tubing is used where there is high vibration.

_____b. When installing rigid tubing, it should be torqued to the exact value as specified in TO.

Answer to Frame 14:

No response required.

Frame 16

Flexible hose is used in high vibration areas. The torque required on flexible hose is specified in the applicable TO. Now at this point, you still have a small problem --- where are the lines? Before you can tighten a line you have to locate it. All pitot and static lines are either color coded, (code will be in TO) or they are taped with the word pitot or static on the line.

Fill in the blanks in the following statement.

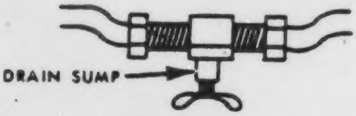
1. Flexible hose and rigid tubing are torqued to value that is specified in ____________ ________________ _______________.

Answer to Frame 15:

__✓__ b.

Frame 17

During an inspection of the pitot-static system, you check the system for moisture. Make sure the drain hole in the pitot-static tube is open and free of dirt. Moisture will also accumulate in the system lines due to condensation. The drain sump (refer to illustration) is used to remove the moisture in the pitot-static system lines.



The drain sumps are located at the lowest point in the pitot and static lines. To remove water from the system lines, you locate the lowest point in the lines and open the drain sumps.

Check (✓) the correct statement/statements.

_____a. The drain sumps are located at the lowest point in the pitot-static lines.

_____b. To insure that water does not accumulate in the pitot or pitot-static tube, keep the drain hole in the tube unclogged.

Answers to Frame 16:

1. the applicable TO.

Frame 18

You have learned about the pitot tube, static flush plate, pitot-static tube, pitot-static lines, drain sumps, rigid tubing, flexible hose and where to find the torque required for the tubing and hose. This last frame pertains to instruments associated with the pitot-static system.

The pitot-static system operates the following list of instruments. You, as an instrument man, are responsible for their maintenance. The operation of these instruments is explained later in this programmed text.

1. Altimeter: indicates the altitude (height of the aircraft above or below sea level).

2. Vertical velocity (rate-of-climb indicator): indicates the rate of climb or dive of the aircraft in feet per minute (fpm).

3. Maximum allowable airspeed indicator; indicates the aircraft's airspeed without correction for altitude or temperature changes, plus the maximum speed at which the aircraft should fly, at any altitude.

4. Machmeter: indicates the aircraft's airspeed in relation to the speed of sound.

Using the illustration on the next page, determine the type pressure or pressures each indicator uses for operation. Place a letter, either a, b or c, by each listed indicator that represents the pressure or pressures used by that indicator.

_____1. altimeter

_____2. maximum allowable airspeed

_____3. vertical velocity

_____4. machmeter

a. pitot pressure

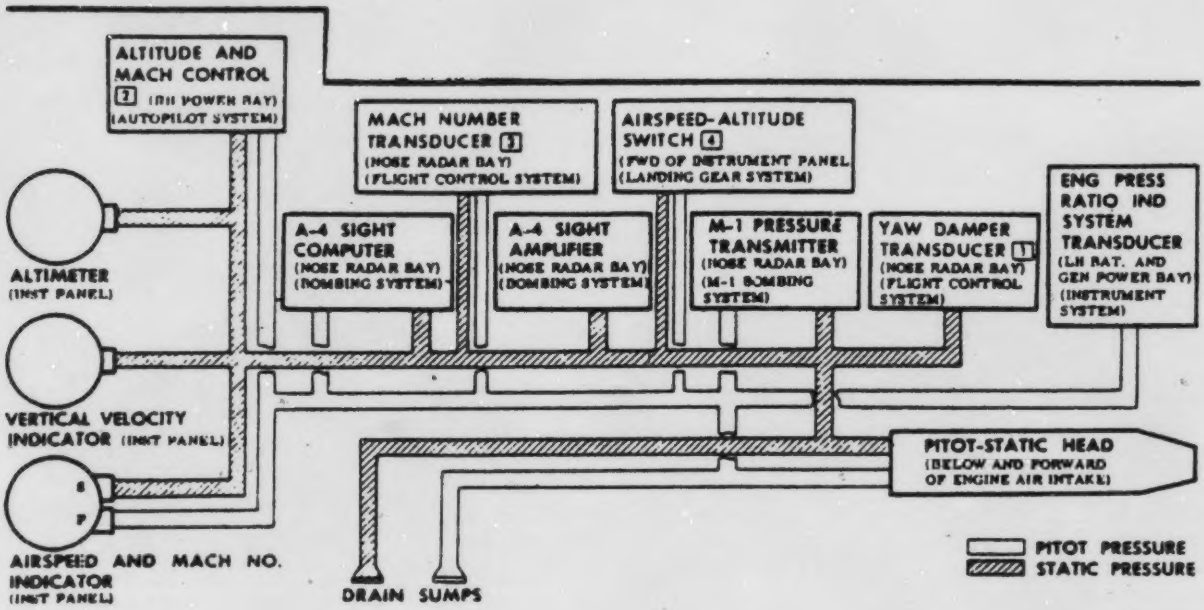
b. static pressure

c. Pitot and static pressure

Answers to Frame 17:

___✓___ a.   ___✓___ b.

1087


ALTITUDE AND MACH CONTROL 2 (RH POWER BAY) (AUTOPILOT SYSTEM)
MACH NUMBER TRANSDUCER 3 (NOSE RADAR BAY) (FLIGHT CONTROL SYSTEM)
AIRSPEED-ALTITUDE SWITCH 4 (FWD OF INSTRUMENT PANEL) (LANDING GEAR SYSTEM)
ENG PRESS RATIO IND SYSTEM TRANSDUCER (LH BAT. AND GEN POWER BAY) (INSTRUMENT SYSTEM)
A-4 SIGHT COMPUTER (NOSE RADAR BAY) (BOMBING SYSTEM)
A-4 SIGHT AMPLIFIER (NOSE RADAR BAY) (BOMBING SYSTEM)
M-1 PRESSURE TRANSMITTER (NOSE RADAR BAY) (M-1 BOMBING SYSTEM)
YAW DAMPER TRANSDUCER 1 (NOSE RADAR BAY) (FLIGHT CONTROL SYSTEM)
ALTIMETER (INST PANEL)
VERTICAL VELOCITY INDICATOR (INST PANEL)
S
P
AIRSPEED AND MACH NO. INDICATOR (INST PANEL)
PITOT-STATIC HEAD (BELOW AND FORWARD OF ENGINE AIR INTAKE)
DRAIN
SUMPS
PITOT PRESSURE
STATIC PRESSURE

Answers to Frame 18:

1. b 2. c 3. b 4. c

1118

1088

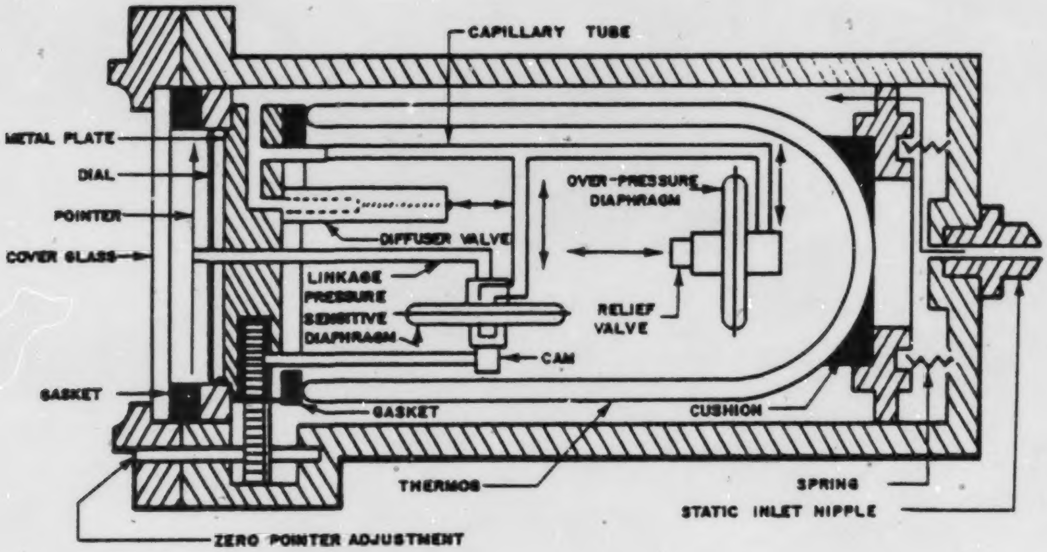
Part I
Section B
VERTICAL VELOCITY INDICATOR

Frame 1

The rate-of-climb or vertical velocity indicator is designed to indicate the rate in feet-per-minute (fpm) at which the aircraft changes altitude. This instrument indicates vertical speed by sensing changes in static pressure as the aircraft changes altitude. The indicator receives static pressure from the pitot-static system and is considered a basic pitot-static instrument.

The vertical velocity indicator serves as a valuable aid to the pilot by allowing him to establish a desired rate-of-climb after takeoff or to establish a desired rate of descent for landing. He may also use the instrument to maintain the aircraft at a constant altitude by keeping the vertical velocity pointer at zero.

Vertical velocity indicators may differ in construction. However, their basic appearance and operation are similar. This allows most vertical velocity indicators to be interchangeable. The illustration below shows the main parts of the Kollsman vertical velocity indicator.


CAPILLARY TUBE
METAL PLATE
DIAL
POINTER
COVER GLASS
OVER-PRESSURE DIAPHRAGM
DIFFUSER VALVE
LINKAGE
PRESSURE SENSITIVE DIAPHRAGM
RELIEF VALVE
CAM
GASKET
GASKET
CUSHION
THERMOS
SPRING
STATIC INLET NIPPLE
ZERO POINTER ADJUSTMENT

Check (✓) the correct statement(s). (More than one statement may be correct.)

The vertical velocity indicator

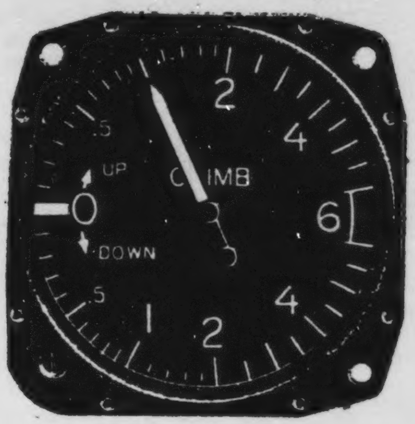
_____a. uses pitot pressure.
_____b. uses static pressure only.
_____c. indicates the rate of climb/dive of the aircraft in feet-per-minute.
_____d. uses pitot and static pressure.

1119

1089

Frame 2

This illustration shown below is a typical vertical velocity indicator. The range of the vertical velocity indicator is 0 to 6,000 feet-per-minute, climb (up) or dive (down). The top half of the dial is marked to indicate the rate of climb, and the bottom half shows the rate of dive. The scale is calibrated in 1000-feet-per-minute increments numbered 0 to 6. Between 0 and 1, the scale is graduated in 100-feet-per-minute increments with a 500-feet (.5) reference for ease of interpretation. Between 1 and 2, the scale is graduated in 200-feet increments. Between 2 and 6, the scale markings are graduated in 500-feet-per minute increments. The large numbers on the dial are thousands of feet-per-minute. When the pointer is on the "1" near the top part of the dial, the aircraft is climbing at a rate of 1000-feet-per-minute.



Circle the letter that identifies the correct answer.

1. If the pointer is at .5 on the dial, the indication is

   a. .5 fpm.

   b. 50 fpm.

   c. 500 fpm.

   d. 5000 fpm.

Answers to frame 1: ✓ b. ✓ c.

1120

You have learned that the vertical velocity indicator uses only static pressure for operation. The pressure measured by the indicator is differential pressure. Differential pressure is the difference between two pressures. You're probably asking yourself, how can it measure the difference between two pressures when the indicator uses only one pressure? This is accomplished with a diffuser valve in the indicator. The diffuser valve creates and maintains a differential pressure when the aircraft is climbing or diving. It also allows the pressure to equalize, and the pointer to return to zero, when the aircraft levels off. The diffuser valve and the expansion and contraction of the sensing element are explained in detail in the next four frames.

Check (✓) the correct statement(s). (More than one statement may be correct.)

1. The vertical velocity indicator

_____a. measures differential pressure.

_____b. uses pitot and static pressure.

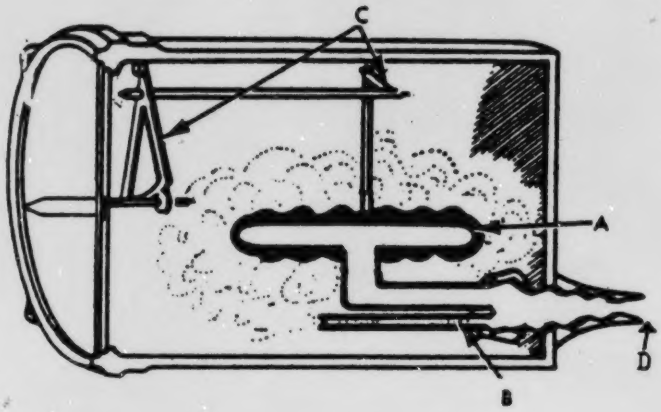
_____c. uses static pressure and measures absolute pressure.

_____d. measures differential pressure and uses static pressure for operation.

Answer to frame 2: 1. c

Frame 4

The figure below shows the indicator's basic mechanism. The sensing element used is a pressure sensitive diaphragm (A). The expansion or contraction of this diaphragm is determined by the pressures acting upon the diaphragm. The diffuser valve (B) is used to create and maintain a differential pressure while the aircraft is climbing or diving. The diffuser valve has a smaller passageway than the passageway that leads to the inside of the pressure sensitive diaphragm. Therefore, the air entering or leaving the case through the diffuser valve in a dive or climb, is slowed down (lagging) or restricted when compared to the air entering or leaving the inside of the diaphragm. These changes in air movement cause the pressure acting upon the diaphragm to change. The pressure inside the diaphragm can change very rapidly because the air movement is not restricted by a small passageway, therefore, diaphragm pressure changes always lead case pressure changes. The differential pressure created by the diffuser valve and measured by the expansion or contraction of the pressure sensitive diaphragm will move mechanical linkage (C) and provide pointer movement to indicate a climb or dive. The mechanism is enclosed in an airtight case with an opening (D) in the rear, to admit static pressure. The next three frames will illustrate the expansion or contraction of the diaphragm.



A. Pressure sensitive diaphragm.
B. Diffuser valve.
C. Mechanical linkage.
D. Static pressure inlet.

Circle the letter that identifies the correct answer.

1. The vertical velocity indicator is used to

   a. measure the change in atmospheric pressure.

   b. measure the change in static pressure.

   c. indicate the vertical speed of climb or dive in feet-per-second.

   d. indicate the vertical speed of climb or dive in feet-per-minute.

2. The sensing element in the vertical velocity indicator is

   a. an over-pressure diaphragm.

   b. a pressure sensitive aneroid.

   c. a diffuser valve.

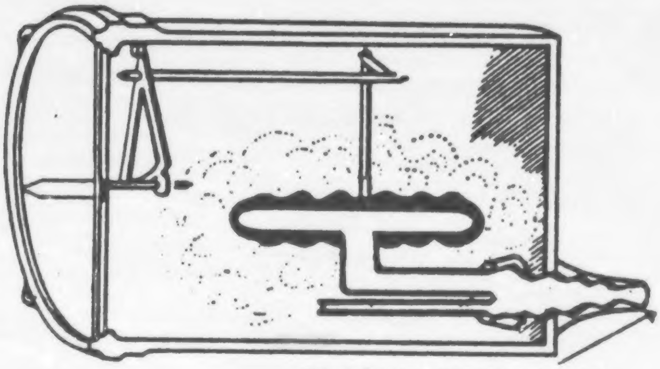
   d. a pressure sensitive diaphragm.

Answers to frame 3: 1. _✓_ a. _✓_ d.

1093

Frame 5

The figure below shows a vertical velocity indicator when the aircraft is in level flight. The pressure is equal on the inside and outside of the diaphragm; therefore, the pointer remains on "zero."



Circle the letter that identifies the correct answer.

1. When the aircraft is on the ground or in level flight, the pressure in the case is

   a. greater than pressure inside the diaphragm.

   b. the same as the pressure in the diaphragm.

   c. less than the pressure in the diaphragm.

   d. creating a differential pressure.

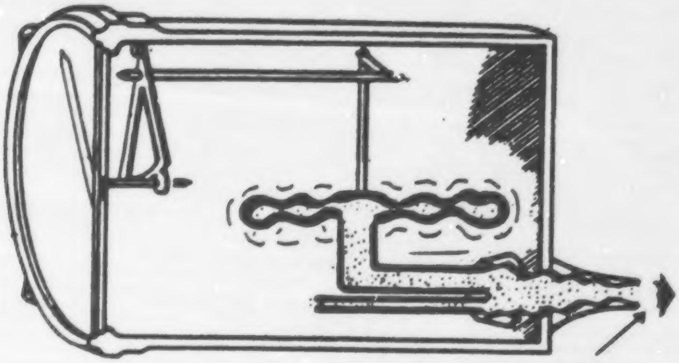
Answer to frame 4: 1. d 2. d

1094

Frame 6

When static pressure changes due to a change in altitude, the change in the pressure surrounding the diaphragm lags the pressure change inside the diaphragm. When there is a change in static pressure, the flow of air to and from the inside of the diaphragm is unrestricted. Air movement to the outside of the diaphragm is restricted or slowed down by the diffuser valve. This causes a differential pressure, and the diaphragm senses this difference and moves the pointer to indicate the rate of altitude change.

The figure below shows what occurs in a climb. As the aircraft gains altitude, the pressure inside the diaphragm decreases. The pressure outside of the diaphragm is changing at a slower rate. Since this change is restricted by the diffuser valve, the pressure on the outside of the diaphragm is greater than the pressure on the inside of the diaphragm. As a result, the diaphragm contracts, causing the pointer to move in a clockwise direction, indicating a climb.



1. Circle the letter(s) that identify the correct statement(s).

   a. The pressure change in the diaphragm lags the pressure change surrounding the diaphragm.

   b. The aircraft changes altitude, the pressure change surrounding the diaphragm lags the pressure change in the diaphragm.

   c. The pointer indicates the altitude of the aircraft.

   d. The sensitive diaphragm measures differential pressure.

   e. The lag in pressure is caused by a restriction in the airflow to and from the inside of the diaphragm.

Frame 6 (Cont'd)

Circle the letter(s) that identify the correct statement(s).

2. In a climb, the pressure on the outside of the diaphragm is:

   a. greater than pressure inside the diaphragm.

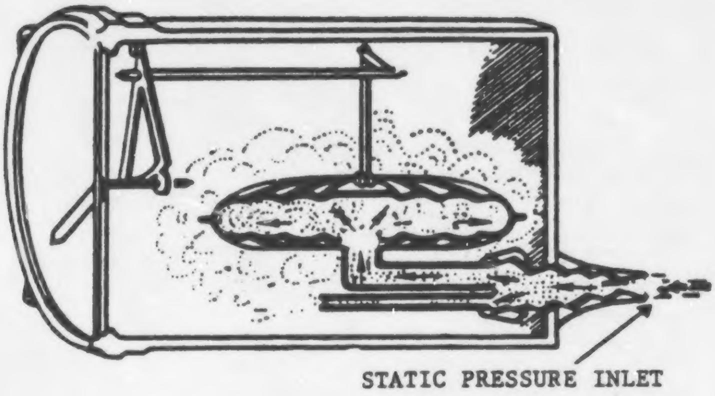
   b. less than pressure inside the diaphragm.

   c. equal to the pressure inside the diaphragm.

   d. referred to as a lagging pressure.

Answer to frame 5: 1. b

The figure below shows that with a decrease in altitude (dive), the pressure in the diaphragm increases at a faster rate than the pressure surrounding the diaphragm because of the diffuser valve. The diaphragm expands, moving the pointer counterclockwise, providing a dive indication.



1. Circle the letter(s) of the correct statement(s).

   a. In a dive, the diaphragm contracts and the pointer moves counterclockwise.

   b. In a dive, the diaphragm expands and the pointer moves counterclockwise.

   c. When the aircraft returns to a level flight, the pressure surrounding the diaphragm and the diaphragm pressure will equalize.

   d. In a dive, the diaphragm expands and the pointer moves clockwise.

   e. In a climb, the diaphragm expands and the pointer moves clockwise.

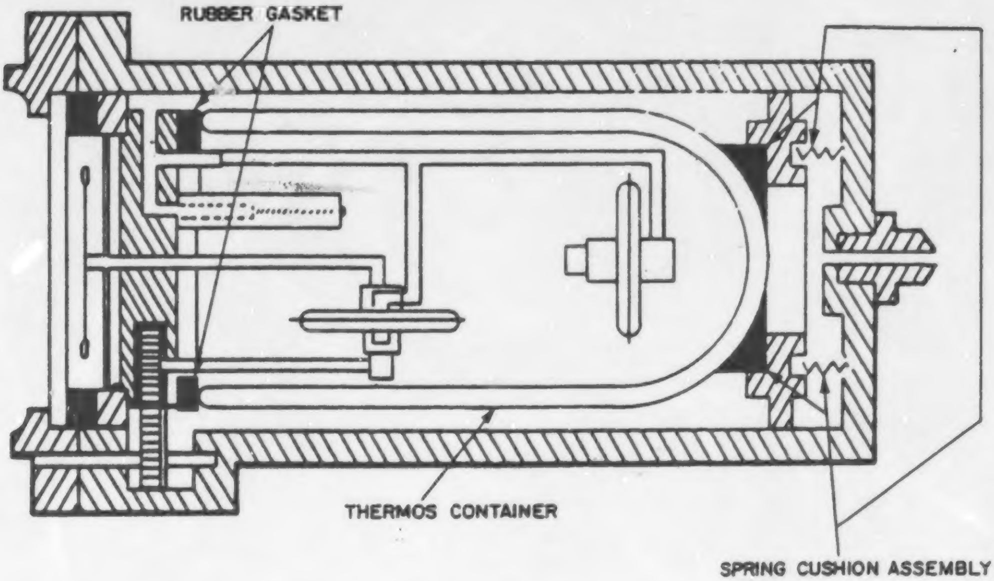
   f. In a climb, the diaphragm contracts and the pointer moves clockwise.

Answers to frame 6: 1. b & d 2. a & d

1097

Frame 8

The temperature compensating unit delays temperature change inside the indicator, thereby preventing unwanted pointer movement. This refers to temperature changes surrounding the indicator. The unit does not compensate for ambient (outside) air temperature changes. The temperature compensating unit is a thermos container. Study the drawing for this frame to see how this thermos container is mounted in the indicator. Without any method of temperature compensation, a change in temperature surrounding the indicator would affect the operation of the indicator by creating a differential pressure.



Circle the letter that identifies the correct answer(s).

1. The thermos container in the indicator
   - a. prevents outside temperature changes.
   - b. causes unwanted pointer movement.
   - c. prevents unwanted pointer movement.
   - d. delays temperature changes in the indicator.

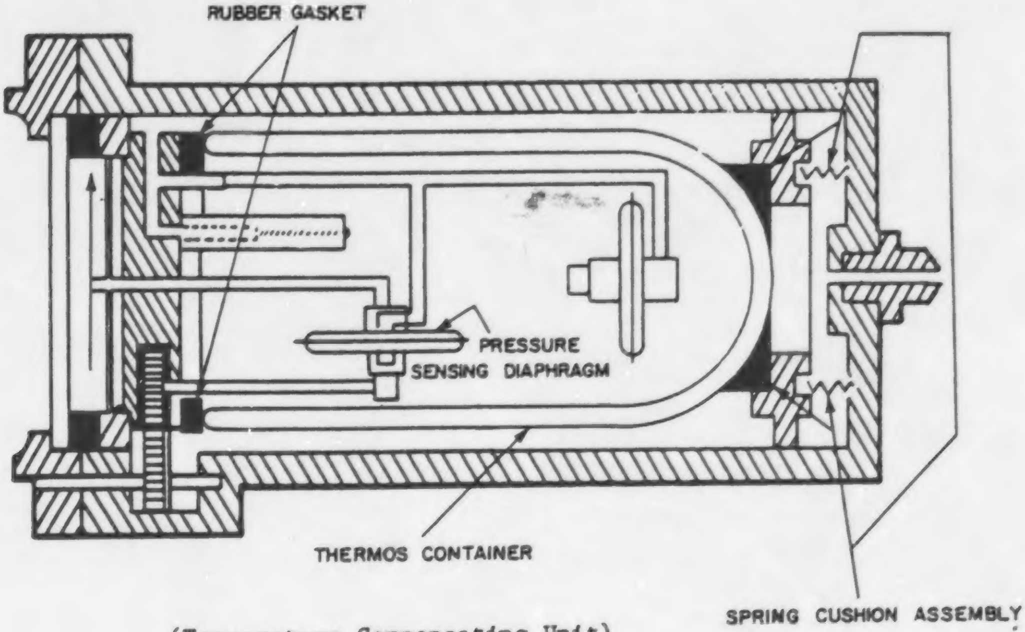
2. The temperature compensator in the indicator is the
   - a. bimetallic coupling.
   - b. pressure sensitive diaphragm.
   - c. container assembly.
   - d. thermos container.

Answers to frame 7: 1. b, c, and f

1128

Frame 9

The spring cushion assembly, shown in the illustration below, holds the thermos tight against a rubber gasket and serves as a shock absorber. This protects the glass thermos from breaking due to vibration of the indicator when it is installed in the aircraft instrument panel. A cracked thermos container will result in equalized pressure on both sides of the pressure sensitive diaphragm. Result--no pointer movement on the indicator.



(Temperature Compensating Unit)

Circle the correct statement(s).

1. The purpose of the spring cushion assembly is to

   a. prevent unwanted pointer movement.

   b. prevent the thermos from breaking when the indicator is dropped.

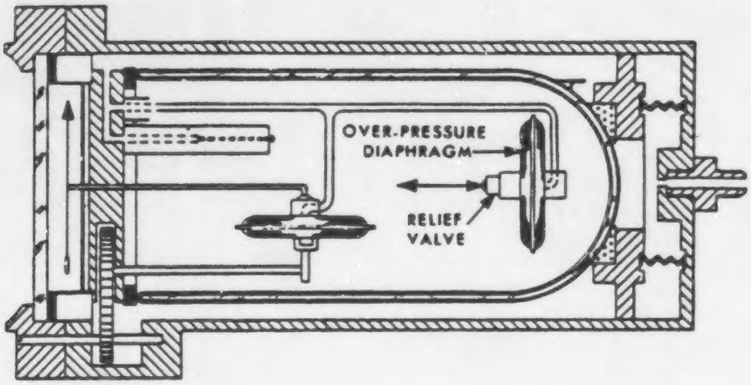
   c. protect the thermos from damage due to vibration.

   d. hold the thermos tight against a rubber gasket.

Answers to frame 8: 1. c & d 2. d

Frame 10

Mechanical devices are installed to prevent damage to the pressure sensitive diaphragm should the vertical speed (climb or dive) of the aircraft exceed the range of the indicator. The indicator uses an overpressure diaphragm with a relief valve. Refer to the illustration below.



Circle the letter that identifies the correct answer.

1. The purpose of the overpressure diaphragm and relief valve is to

   a. stop the pointer at zero.

   b. prevent damage to the thermos container.

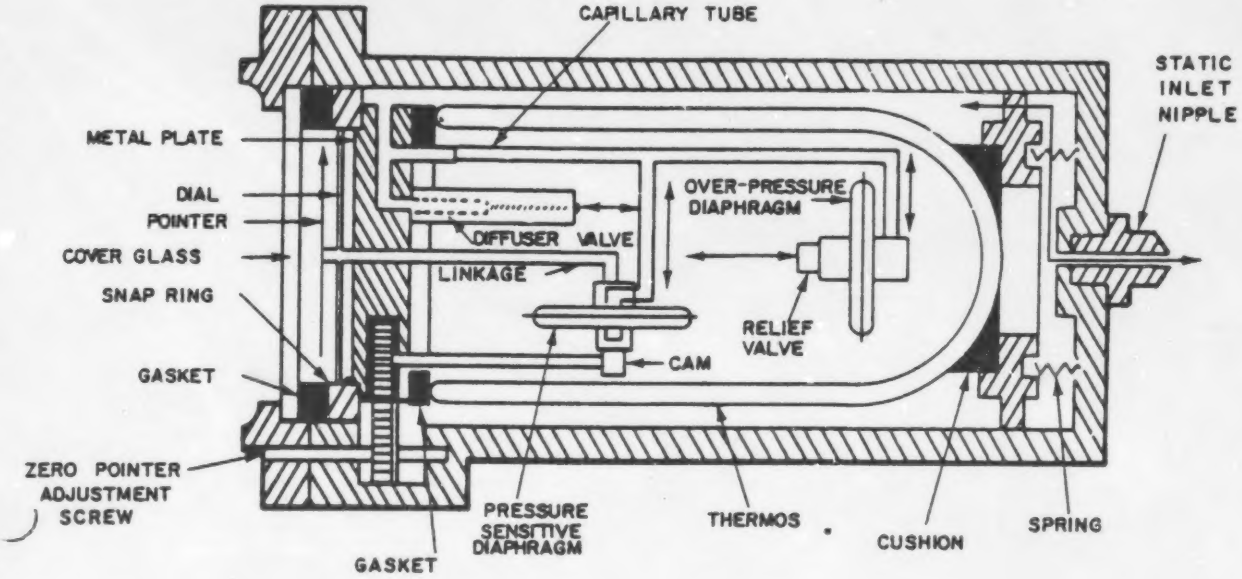
   c. prevent damage to the diffuser valve.

   d. prevent damage to the pressure sensitive diaphragm.

Answer to frame 9: 1. c & d

Frame 11

A zero pointer adjustment screw is located on the front of the indicator. This screw is used to set the pointer on zero to correct for secular error. The error is caused mainly by internal stresses and wear of the indicating mechanism. This can cause the pointer to be off the zero mark. Refer to the illustration below for the location of various components of the rate of climb indicator.


CAPILLARY TUBE
STATIC INLET NIPPLE
METAL PLATE
DIAL
POINTER
COVER GLASS
SNAP RING
GASKET
ZERO POINTER ADJUSTMENT SCREW
OVER-PRESSURE DIAPHRAGM
DIFFUSER VALVE
LINKAGE
RELIEF VALVE
CAM
PRESSURE SENSITIVE DIAPHRAGM
THERMOS
CUSHION
SPRING
GASKET

Circle the letter that identifies the correct answer.

1. The pointer may be reset to "zero" by turning the

   a. zero adjustment screw located on the back of the indicator.

   b. error knob.

   c. reset knob.

   d. zero adjustment screw located on the front of indicator.

Answer to frame 10: 1. d
Answer to frame 11: 1. d

Part I
Section C
ALTIMETER

Frame 1

The purpose of the altimeter is to indicate the altitude of the aircraft, in feet, above or below sea level. To do this properly, the altimeter is connected to the pitot static system and uses static pressure only for operation.

Circle the letter of the correct answer below.

1. What instrument uses static pressure to give an indication of feet above or below sea level?

    a. Altimeter.

    b. Vertical velocity indicator.

    c. Airspeed indicator.

    d. True airspeed indicator.

Frame 2

The element in the altimeter case that senses the static pressure is the sensitive aneroid. There is usually more than one aneroid so that greater accuracy can be obtained. The sensing aneroids expand and contract with a change in pressure. The sensing aneroids are sealed to a near perfect vacuum. Only static pressure that surrounds the aneroids in the instrument case affect expansion or contraction of the aneroids. The aneroids measure absolute pressure; that pressure above or below a zero reference (that being the vacuum inside the aneroid).

Circle the letter of the correct answer below.

1. The elements that sense static pressure in the altimeter are
   - a. aneroids.
   - b. diaphragms.
   - c. bellows.
   - d pressure sensitive bellows.
2. The altimeter uses what type of pressure?
   - a. Static pressure only.
   - b. Pitot and static pressure.
   - c. Impact pressure only.
   - d. Impact pressure plus static pressure.
3. The aneroids measure what type of pressure?
   - a. Pitot and static pressure.
   - b. Static pressure only.
   - c. Absolute pressure.
   - d. Impact pressure.

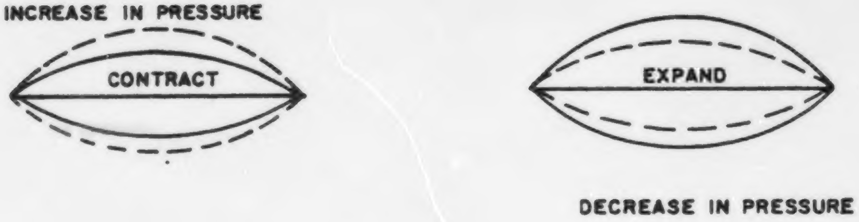
Answer to frame 1

1. a

11.03.

Frame 3

The aneroids of an altimeter respond to changes in static pressure as shown in the illustration below. An increase in pressure causes the aneroid to contract, whereas a decrease in pressure causes the aneroid to expand.


INCREASE IN PRESSURE
CONTRACT
EXPAND
DECREASE IN PRESSURE

Using the above illustration, circle the correct answer(s) below.

1. The aneroids of an altimeter will

   a. expand with a decrease in static pressure.

   b. expand with an increase in static pressure.

   c. contract with a decrease in static pressure.

   d. contract with a decrease in pitot pressure.

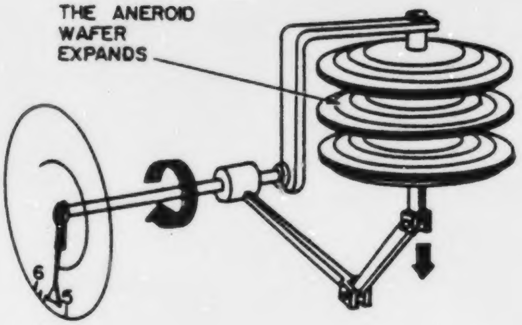
Answer to frame 2

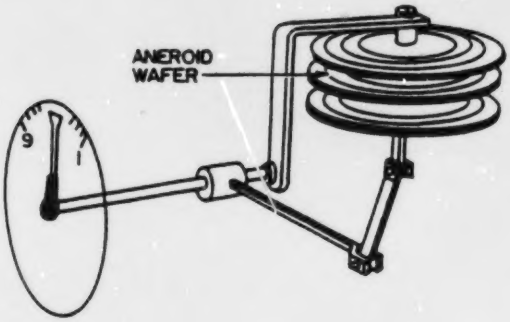
1. a 2. a 3. c.

1134

Frame 4

When the aneroids expand, the pointers of the altimeter rotate clockwise, indicating an increase in altitude (refer to illustration below). When the aircraft decreases altitude the aneroids will contract causing the pointer to indicate a decrease in altitude.





Using the above illustration, circle the correct answer(s) below.

1. The expansion of the aneroids will cause the pointer to indicate

   a. an increase in altitude.

   b. an increase in pressure.

   c. a decrease in altitude.

   d. an increase in pressure and altitude.

Answer to frame 3

1. a

1105

Frame 5

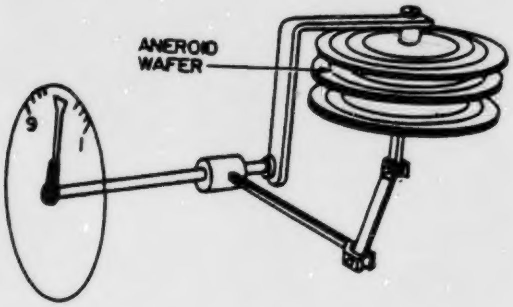
Circle the correct answer to the following questions.

1. The sensitive elements of the altimeter which sense static pressure are called:

   a. aneroids.

   b. diaphragms.

   c. bellows.



2. If the static pressure increases around the altimeter aneroids, the pointers would

   a. move upscale (increase in reading).

   b. move downscale (decrease in reading).

   c. remain the same.

3. With an increase in altitude, what happens to static pressure?

   a. The pressure stays the same.

   b. The static pressure increases.

   c. The static pressure decreases.

Answer to frame 4

1. a

1138

Frame 6

So far you have covered the purpose of the altimeter, its sensing element, and the effect of pressure changes. Now you will learn how to read the altimeter. Reading the three pointer altimeters is easy if you remember to read the triangular tipped (inverted) pointer first, the intermediate (short) pointer next, and the long pointer last.

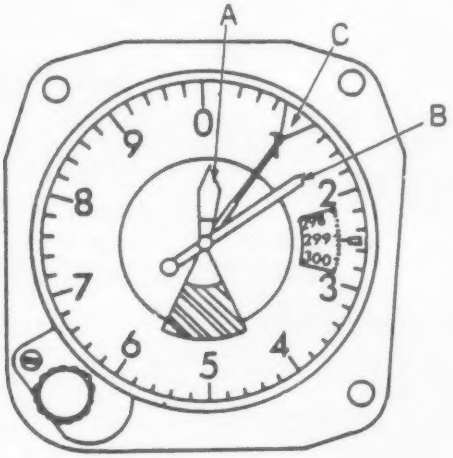
NO RESPONSE REQUIRED.

Answer to frame 5

1. a 2. b 3. c

Frame 7

Refer to the illustration below. The inverted pointer (C) indicates tens of thousands of feet, the intermediate (A) (short) pointer indicates thousands of feet, and the long (B) pointer indicates hundreds of feet.

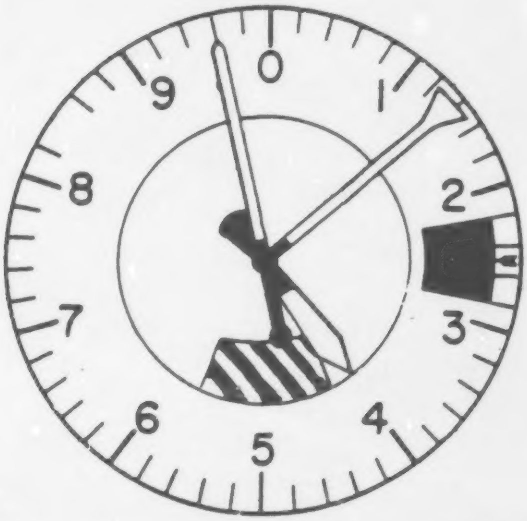


Using the illustration as a reference, match the pointers in column B with their purpose in column A.

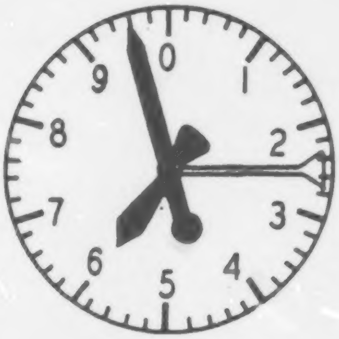
	A		B
1._____	indicates hundreds of feet.	a.	intermediate pointer
2._____	indicates thousands of feet.	b.	long pointer
3._____	indicates tens of thousands of feet.	c.	inverted pointer

Frame 8

When reading the altimeter, you read it in the following manner. The inverted and short pointers are read to the last whole number. Look at the inverted pointer below, it is between the 1 and 2 so you read the 1. When reading the inverted pointer, each whole number equals 10,000 feet. Reading the illustration below, the inverted pointer is indicating 10,000 feet. The short pointer below indicates in thousands of feet and since it is not quite on the 4, the short pointer indicates 3,000 feet. Every increment is read on the long pointer and each increment indicates 20 feet. In the illustration below, the long pointer indicates 960 feet. To get the total altimeter reading, find the sum of each of the pointers. Example: 10,000 + 3,000 + 960 = 13,960 feet.



Read the dial below and fill in the blank spaces below.



a. The inverted pointer indicates ___________________ feet.

b. The short pointer indicates ___________________ feet.

c. The long pointer indicates ___________________ feet.

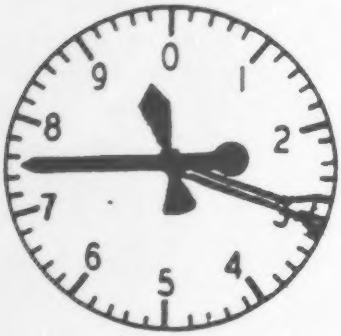
d. The total indication (altimeter reading) is _________________.

Answers to frame 7

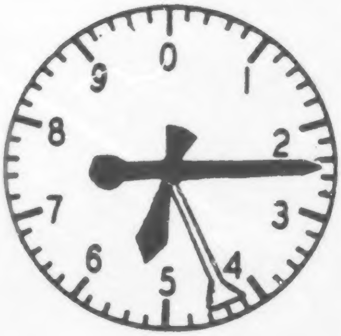
1. b   2. a   3. c

Frame 9

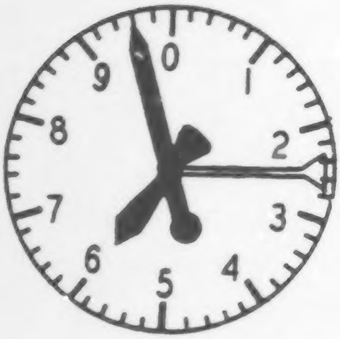
Read the following dials and enter the altimeter readings in the spaces provided.


0
1
2
3
4
5
6
7
8
9

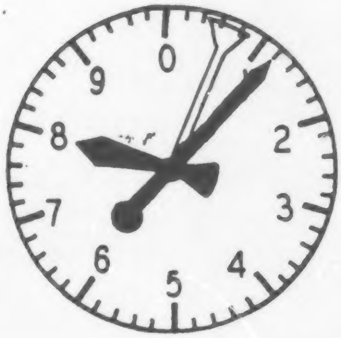
1. ________


0
1
2
3
4
5
6
7
8
9

2. ________


0
1
2
3
4
5
6
7
8
9

3. ________



4. ________

Answers to frame 8

a. 20,000'   b. 5,000'   c. 960'   d. 25,960'

Frame 10

If you missed two or more readings in frame 9, go to frame 11 and review. If you missed one or less, proceed to frame 13.

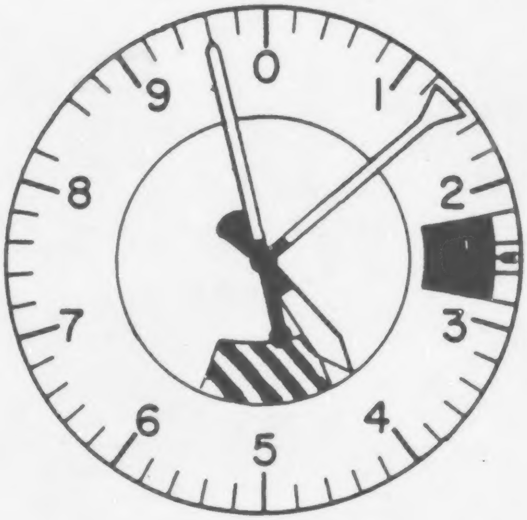
Answers to frame 9

1. 29,750'   2. 45,250'   3. 25,960'   4. 8,120'

Frame 11

You seem to be having trouble reading the altimeter, so look at the altimeter again. In the illustration below, take a look at the dial. The inverted pointer indicates 10,000' and is multiplied by the last whole number. (Example: 10,000' X 1 = 10,000'.) The next pointer is the short pointer which indicates 1,000' multiplied by the last whole number (1,000' X 3 = 3,000'). The long pointer is the 100' pointer and must be multiplied by the last numbered increment that it has passed. (Example: 100' X 9 = 900'.) Also with the long pointer, and only the long pointer, you read the increments. Each increment is equal to 20 feet. Since the pointer is on the 3d increment past the 9, the hundred foot pointer is indicating 960'. Now add the three pointer indications and you have the correct altimeter reading. Example: 10,000' + 3,000' + 960' = 13,960'.

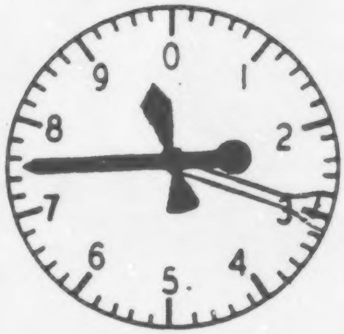
NO RESPONSE REQUIRED



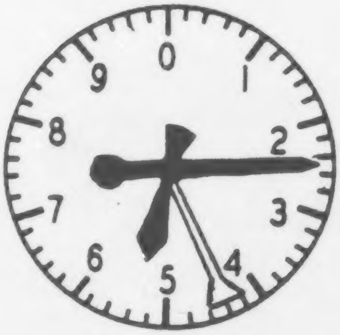
IIH

Frame 12

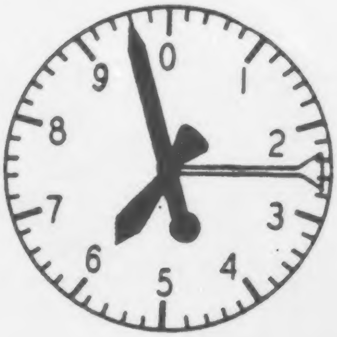
Read the following dials and enter the altimeter readings in the spaces provided below.


0
1
2
3
4
5
6
7
8
9

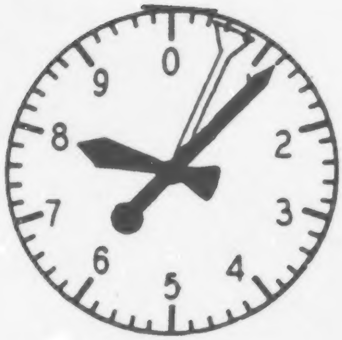
1. ________


0
1
2
3
4
5
6
7
8
9

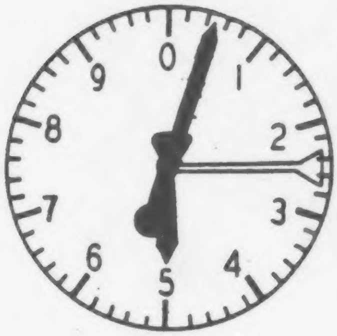
2. ________


0
1
2
3
4
5
6
7
8
9

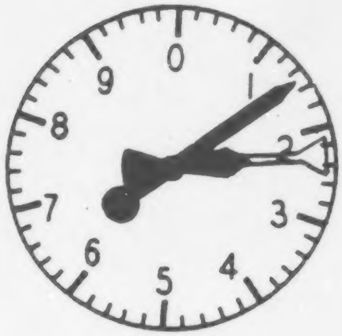
3. ________


0
1
2
3
4
5
6
7
8
9

4. ________


0
1
2
3
4
5
6
7
8
9

5. ________


0
1
2
3
4
5
6
7
8
9

6. ________

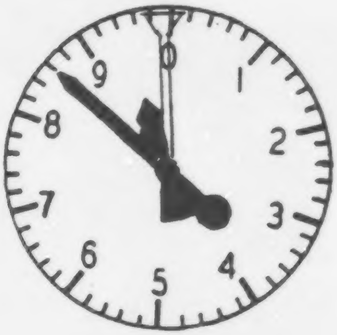
If you know how to read the altimeter, proceed to frame 13 and continue with the programmed text. If you are still having difficulty, see your instructor.

Answer to frame 11

NO RESPONSE REQUIRED

1142

We have indicated that the altimeter indicates altitude above and below sea level. All of the indications you read in frames 9 and 11 were all above sea level. Suppose now the aircraft is flying below sea level. How do you read the altimeter in the negative direction? We read the altimeter starting with the inverted pointer first, the short pointer next, and the long pointer last. To read the pointers in the negative direction we read the pointers in the same manner but with one important change. We must transpose the numbers on the dial mentally. Change the number nine to one, number eight to number two, number seven to number three and so on. All the pointers will be to the left of the zero on the dial as in the illustration.

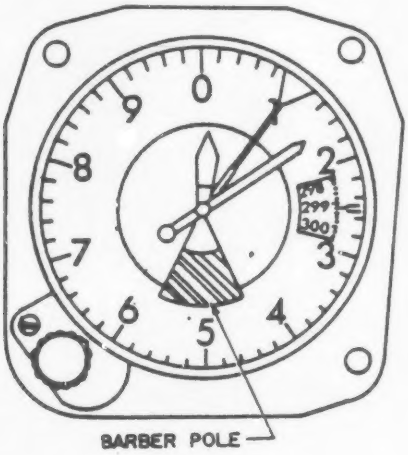


NO RESPONSE REQUIRED.

1113

Frame 14

Another part of the altimeter face is the barber pole (crosshatch) as shown in the illustration below. The barber pole is a low altitude warning symbol that is in view below 16,000 feet and disappears from view when the aircraft is between 16,000 and 17,000 feet.



Using the above illustration, circle the correct answer(s) below.

1. The barber pole is visible between

   a. 271 feet to 15,978 feet.

   b. 17,000 feet to 28,127 feet.

   c. 25,000 feet to 26,000 feet.

   d. -126 feet to 15,999 feet.

Answer to frame 12

1.	29,750 feet.	2.	45,250 feet.	3.	25,960 feet.
4.	8,120 feet.	5.	25,050 feet.	6.	22,150 feet.

1144

Frame 15

The Barometric (Baro) scale on the face of the altimeter shown below is used to indicate a reference point that is set into the altimeter. The barometric scale is calibrated in inches of mercury which is abbreviated "Hg".

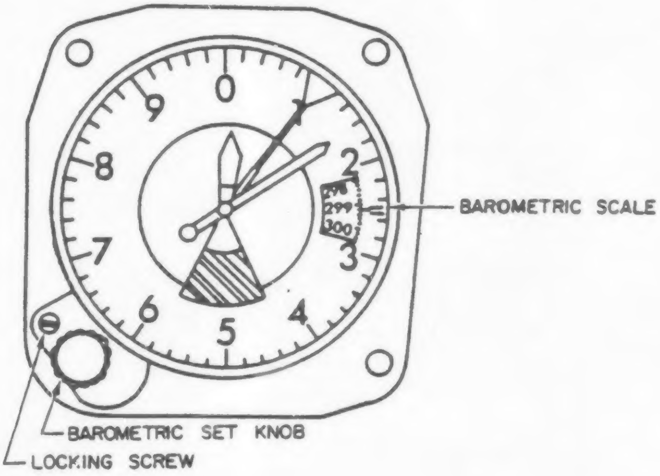
Circle the correct answer(s) below.

1. The purpose of the baro scale is to

   a. indicate altitude.

   b. act as a warning device.

   c. indicate a reference point.


0
1
2
3
4
5
6
7
8
9
298
299
300
BAROMETRIC SCALE
BAROMETRIC SET KNOB
LOCKING SCREW

Answer to frame 14

1. a, d

Frame 16

The altimeter is similar to a clock. No matter how precise it is, it must be correctly set to provide a correct altitude indication. The altimeter has a barometric set knob which is shown in frame 15 illustration. This knob is used to set the correct reference point in the altimeter.

Circle the correct answer below.

1. What is used to set the correct reference point on the barometric scale?

   a. Set screw.

   b. Barometric set knob.

   c. Barometric scale.

Answer to frame 15

1. c

Frame 17

The altimeter's pointers indicate the altitude above the reference point placed on the barometric scale. The barometric scale never moves except when the barometric set knob is turned.

Circle the correct answer(s) below.

1. A change in altitude will cause the

   a. barometric scale to move.

   b. pointers and barometric scale to move.

   c. pointers to move.

Answer to frame 16

1. b

Frame 18

The barometric (baro) set knob locking screw is located above the baro set knob as shown in frame 15. This screw is used to unlock the baro set knob. This allows you to pull the baro set knob out and perform an altimeter setting adjustment which is explained in detail in WB-301B.

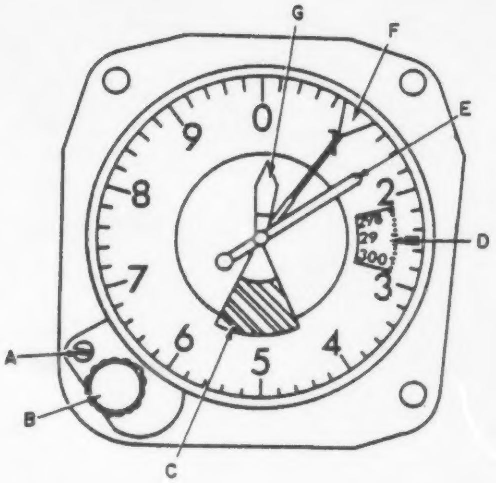
NO RESPONSE REQUIRED

Answer to frame 17

1. c

Frame 19

Match the names of the components parts in column A to the letters on the illustration, by placing the appropriate letter in the space provided.



Column A

_____1. Tens of thousands of feet pointer.

_____2. Thousands of feet pointer.

_____3. Hundreds of feet pointer.

_____4. Baro set knob.

_____5. Barometric scale.

_____6. Set screw.

_____7. Barber pole.

Answer to frame 18

NO RESPONSE REQUIRED

There are two main reference points normally used in setting the altimeter. They are sea level pressure for the barometric scale and field elevation for the pointers.

Circle the correct answer(s) below.

1. The reference points normally used in setting the altimeter are:

   a. barometric pressure and sea level pressure.

   b. pressure altitude and barometric pressure.

   c. sea level pressure and field elevation.

   d. local pressure and pressure altitude.

Answers to frame 19

1. F 2. G 3. E 4. B 5. D 6. A 7. C

1150

Sea level is the average height of all large bodies of water between high and low tides. This is designated "0" feet. It is a common reference point for altitude and pressure. On a standard day the pressure at sea level is 29.92" Hg and the temperature is 15°C. It is to these standard conditions that the altimeter is calibrated.

Circle the correct answer(s) below.

1. The elevation of sea level on a standard day is:
   a. -1000 feet.
   b. "0" feet.
   c. 100 feet.
   d. 29.92" Hg.

2. The pressure at sea level on a standard day is:
   a. "0" feet.
   b. 29.92" Hg.
   c. 22.22" Hg.
   d. 100 feet.

3. The average height of all large bodies of water between high and low tides is called:
   a. pressure altitude.
   b. sea level.
   c. altimeter setting.
   d. local pressure.

Answer to frame 20

1. c

1121

Frame 22

Pressure altitude is the surrounding atmospheric pressure expressed in feet and is indicated on the calibrated altimeter pointers when the barometric scale is set to 29.92 inches of mercury ("Hg).

Circle the correct answer(s) below.

1. The definition of pressure altitude is

    a. sea level.

    b. surrounding atmospheric pressure expressed in feet.

    c. local pressure.

2. If the barometric scale of a calibrated altimeter is adjusted to 29.92" Hg, the pointers always indicate

    a. altitude above sea level.

    b. pressure altitude.

    c. sea level.

Answers to frame 21

1. b 2. b 3. b

1152

Local pressure is the surrounding atmospheric pressure, obtained from a barometer, and is expressed in inches of mercury.

Select the correct answer(s) below.

1. The surrounding atmospheric pressure expressed in inches of mercury is called
   a. sea level.
   b. pressure altitude.
   c. local pressure.
2. Pressure altitude converted into inches of mercury is called
   a. local pressure.
   b. sea level.
   c. pressure altitude.

Answers to frame 22

1. b   2. b

Frame 24

When the altimeter is adjusted correctly, the existing sea level pressure is set on the barometric scale and field elevation is set on the altimeter's pointers. The definition of altimeter setting is local pressure corrected to the existing sea level pressure.

Select the correct answer below.

1. Local pressure corrected to the existing sea level pressure is called

   a. pressure altitude.

   b. altimeter setting.

   c. local pressure.

   d. sea level.

Answers to frame 23

1. c 2. a

Frame 25

Field elevation is defined as the surveyed elevation of a tract of land above or below sea level. Another way to state it is, the actual height of the runway above sea level.

Circle the letter of the correct answer below.

1. The surveyed height of a tract of land above or below sea level is called

   a. pressure altitude.

   b. field elevation.

   c. sea level.

Answer to Frame 24:

1. b

Answer to Frame 25:

1. b

1125

Part I
Section D
MAXIMUM ALLOWABLE AIRSPEED INDICATOR

Frame 1

The Air Force uses many different types of airspeed indicators, but all operate on the same basic principles. The maximum allowable airspeed indicator has two separate sections, (1) the indicated airspeed section and (2) the maximum allowable airspeed section.

By studying each section of the maximum allowable airspeed indicator, all basic principles of operation will be covered.

Circle the letter that identifies the correct answer.

1. How many separate sections are in the maximum allowable airspeed indicator?

    a. 1.

    b. 2.

    c. 3.

    d. 4.

1156

INDICATED AIRSPEED SECTION

Frame 2

Two of the most important flight characteristics of an aircraft are (1) the minimum takeoff and landing speed and (2) the maximum speed the aircraft may fly without causing structural damage or loss of control.

The purpose of the indicated airspeed section is to display the airspeed of the aircraft without correction for temperature or altitude. This uncorrected airspeed is called indicated airspeed.

The indicated airspeed will aid the pilot in determining when he has reached his minimum takeoff speed, minimum landing speed, or maximum allowable airspeed.

> Example: If the aircraft's minimum takeoff speed is 130 knots, then the pilot must be able to determine when he has reached his takeoff speed of 130 knots. The indicated airspeed section will display the indicated airspeed of the aircraft.

Circle the letter that identifies the correct answer.

1. What is the purpose of the indicated airspeed section?

   a. Measure true Mach.

   b. Display true airspeed.

   c. Display indicated airspeed.

   d. Measure maximum allowable airspeed.

Answers to frame 1:

1. b

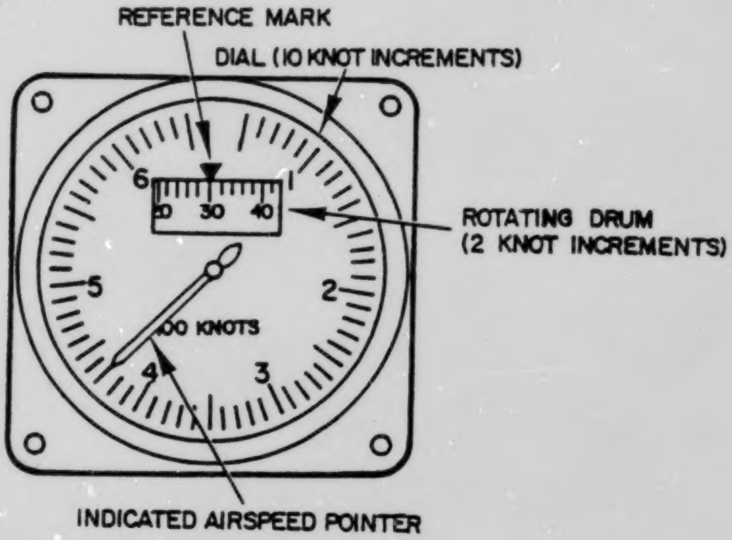
1127

Frame 3

The indicated airspeed section has a dial marked in 10 knot increments and a rotating drum that is marked in 2 knot increments. The rotating drum aids the pilot in reading the indicator quickly and accurately.

The large numbers represent hundreds of knots. In the figure below, the solid white pointer (indicated airspeed pointer) is past the 400 knot reading but before the 500 knot reading. The rotating drum is indicating 30 knots with respect to the reference mark. Therefore the indicator is displaying an indicated airspeed of 430 knots.

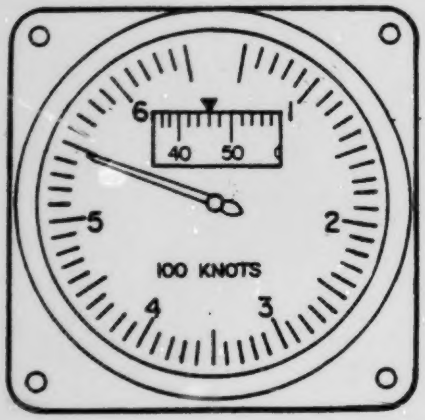
Note: It is easier to read the rotating drum than to count the increments between the large numbers.


REFERENCE MARK
DIAL (10 KNOT INCREMENTS)
6
1
20 30 40
ROTATING DRUM
(2 KNOT INCREMENTS)
5
2
100 KNOTS
4
3
INDICATED AIRSPEED POINTER

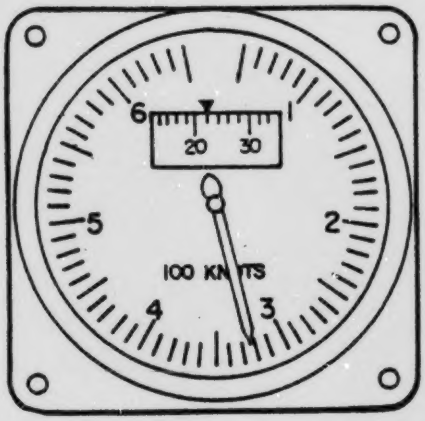
Answer to frame 2:

1. c

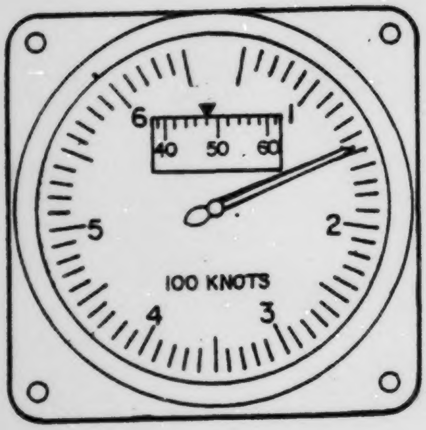
Read and record the position of the indicated airspeed pointer in each of the following examples. Place your answers in the spaces provided.


6
1
40
50
0
5
2
100 KNOTS
4
3

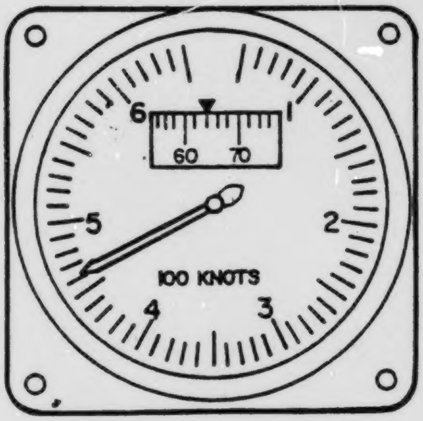
1. __________ knots


6
1
20
30
5
2
100 KNOTS
4
3

2. __________ knots


6
1
40
50
60
5
2
100 KNOTS
4
3

3. __________ knots


6
1
60
70
5
2
100 KNOTS
4
3

4. __________ knots

Frame 4

The indicated airspeed reading is a direct result of pressures acting on the sensing element. A component capable of detecting a change is called a sensing element. The sensing element of the indicated airspeed section is the airspeed diaphragm. The airspeed diaphragm is capable of detecting a change in the aircraft's speed by sensing pressure changes.

Circle the letter that identifies the correct answer.

1. What is the sensing element of the indicated airspeed section?
    a. Aneroid.
    b. Airspeed diaphragm.
    c. Airspeed indicator.
    d. Absolute mechanism.
2. What is the purpose of the indicated airspeed section?
    a. Measure true mach.
    b. Display true airspeed.
    c. Display indicated airspeed.
    d. Measure maximum allowable airspeed.

Answers to frame 3:

1. 546 knots 2. 322 knots 3. 148 knots 4. 464 knots

How does an airspeed diaphragm detect a change in the aircraft's speed? The programmed text, The Pitot Static System, referred to pitot pressure as total pressure. Pitot pressure is total pressure. The terms "pitot" and "total" may be used interchangeably. In the programmed text you learned that pitot pressure was made up of static pressure and impact pressure.

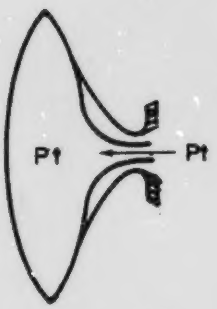
PITOT (TOTAL) PRESSURE = STATIC PRESSURE + IMPACT PRESSURE

(Pt) = (Ps) + (Qc)

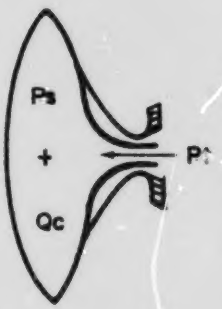
Pt = Ps + Qc

Therefore, if total pressure is sent to the inside of the airspeed diaphragm, static pressure and impact pressure are inside the diaphragm. (See the illustrations below.)

Keep in mind that Pt is equal to Ps + Qc.



DIAPHRAGM "A"



DIAPHRAGM "B"

Circle the letter that identifies the correct answer.

1. Which of the following terms describes Ps + Qc?

   a. Total pressure.

   b. Static pressure.

   c. Impact pressure.

   d. Differential pressure.

2. If you had a bottle full of total pressure, what pressure/s would be on the inside of the bottle?

   a. Static pressure.

   b. Impact pressure.

   c. Static pressure plus impact pressure.

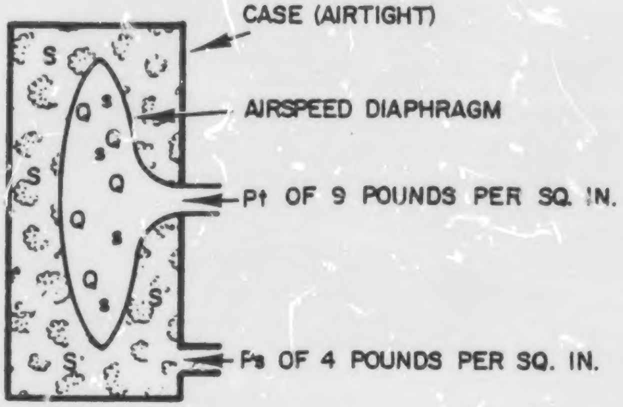
   d. Static pressure minus impact pressure.

Answers to frame 4:

1. b. 2. c.

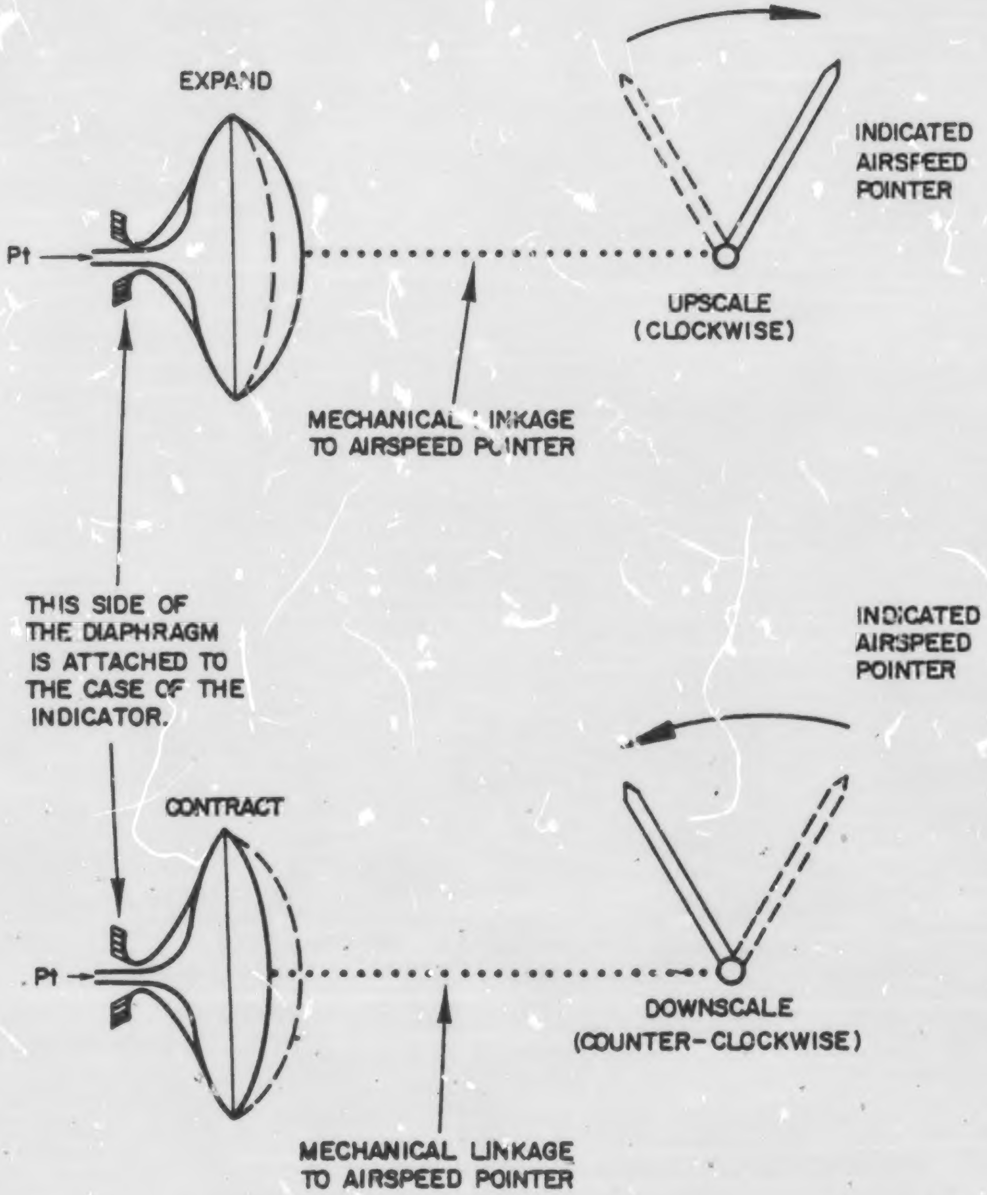
Frame 6

The indicated airspeed section uses pitot and static pressure inputs. When the case of the indicator is filled with static pressure from the pitot-static system, the static pressure will surround the airspeed diaphragm, as shown below.



Example: An aircraft is maintaining a constant altitude of 32,000 feet and a constant speed of 400 knots. At 32,000 feet the static pressure is 4 pounds per square inch. If the aircraft's pitot pressure is 9 psi, it is made up of 4 psi static pressure and 5 psi of impact pressure produced by the aircraft's forward movement. The figure above will show how these pressures affect the airspeed diaphragm.

Ps inside the diaphragm and Ps on the outside of the diaphragm are equal. If one Ps value changes, the other must also change because they both come from the same air outside the aircraft. With Ps on the inside of the diaphragm being equal to the Ps on the outside of the diaphragm, the pressures will effectively cancel each other. The expansion of the diaphragm in the figure above is completely due to the pressure being applied to the interior wall of the airspeed diaphragm by the 5 psi of impact pressure. The airspeed diaphragm is measuring a differential pressure. It is measuring the difference between static pressure and pitot pressure. As the aircraft goes faster, impact pressure increases. As Qc increases so does the indicated airspeed. The figure on the next page shows the airspeed diaphragm's expansion and contraction and its effect on the airspeed pointer.


EXPAND
INDICATED AIRSPEED POINTER
Pt
UPSCALE (CLOCKWISE)
MECHANICAL LINKAGE TO AIRSPEED POINTER
THIS SIDE OF THE DIAPHRAGM IS ATTACHED TO THE CASE OF THE INDICATOR.
INDICATED AIRSPEED POINTER
CONTRACT
Pt
DOWNSCALE (COUNTER-CLOCKWISE)
MECHANICAL LINKAGE TO AIRSPEED POINTER

Circle the letter that identifies the correct answer.

1. A contraction in the size of the airspeed diaphragm will cause the indicated airspeed pointer to

   a. move upscale.

   b. move downscale.

   c. move clockwise.

   d. remain at its last indication.

2. As the aircraft goes faster, Qc will

   a. decrease and cause the sensing element to expand.

   b. increase and cause the sensing element to expand.

   c. decrease and cause the sensing element to contract.

   d. increase and cause the sensing element to contract.

3. What type of pressure is measured by the sensing element of the indicated airspeed section?

   a. Absolute pressure.

   b. Sensitive pressure.

   c. Differential pressure.

   d. Absolute and differential pressure.

4. When Ps inside the diaphragm and Ps outside the diaphragm cancel each other, what pressure will determine indicated airspeed?

   a. Pitot pressure.

   b. Total pressure.

   c. Static pressure.

   d. Impact pressure.

5. A differential pressure may be described as

   a. the sum of two pressures.

   b. the difference between two pressures.

   c. a pressure that is based on an absolute value.

6. What is the differential pressure if Pt = 14 psi and Ps = 8 psi?

   a. 4 psi.

   b. 6 psi.

   c. 16 psi.

   d. 22 psi.

7. What is the differential pressure if Pt = 23 psi and Ps = 2 psi?

   a. 11 psi.

   b. 21 psi.

   c. 25 psi.

   d. 27 psi.

Answers to frame 5

1. a. 2. c

The steps listed below describe the movement of the components shown in the figure on the next page.

Description of component movement:

1. The airspeed diaphragm's expansion or contraction will cause shaft "A" to move along centerline "CL."

2. Movement of shaft "A" will produce a rotation of shaft "B" at pivot point "P".

3. Shaft "B" will cause sector gear "X" (section of a gear) to move.

4. When sector gear "X" moves, shaft "C" will rotate causing the airspeed drum to rotate and the airspeed pointer to move.

Circle the letter that identifies the correct answer.

1. As the airspeed diaphragm expands, shaft "B" will rotate
   a. clockwise.
   b. counterclockwise.

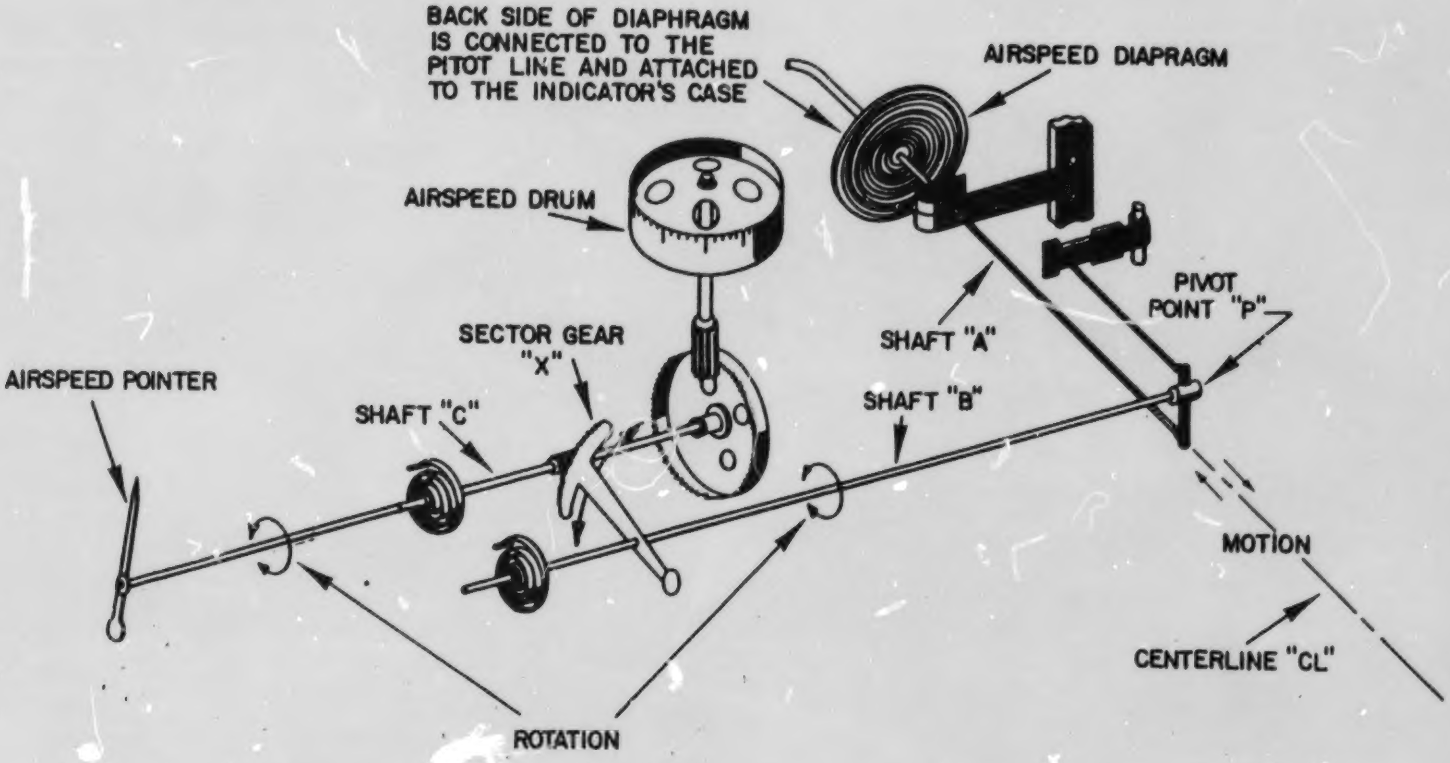
2. As the airspeed diaphragm expands, the rotation of shaft "B" will cause the indicated airspeed pointer to
   a. move clockwise.
   b. move counterclockwise.
   c. remain at its last indication.

Answers to Frame 6:

1. b. 2. b. 3. c. 4. d

5. b. 6. b. 7. b.

H37


BACK SIDE OF DIAPHRAGM IS CONNECTED TO THE PITOT LINE AND ATTACHED TO THE INDICATOR'S CASE
AIRSPEED DIAPRAGM
AIRSPEED DRUM
SECTOR GEAR "X"
SHAFT "A"
PIVOT POINT "P"
AIRSPEED POINTER
SHAFT "C"
SHAFT "B"
MOTION
CENTERLINE "CL"
ROTATION

6911

1168

Circle the letter that identifies the correct answer.

1. How many separate sections are in the maximum allowable airspeed indicator?

   a. 1.

   b. 2.

   c. 3.

   d. 4.

2. What is the purpose of the indicated airspeed section?

   a. Measure true mach.

   b. Display true airspeed.

   c. Display indicated airspeed.

   d. Measure maximum allowable airspeed.

3. What is the sensing element of the indicated airspeed section?

   a. Aneroid.

   b. Airspeed diaphragm.

   c. Airspeed indicator.

   d. Absolute mechanism.

4. What type of pressure is measured by the sensing element of the indicated airspeed section?

   a. Absolute pressure.

   b. Sensitive pressure.

   c. Differential pressure.

   d. Absolute and differential pressure.

5. What pressures are supplied to the indicated airspeed section to allow the sensing element to determine indicated airspeed?

a. Ps and Qc.

b. Qc and Pt.

c. Pt and Ps.

d. Qc and Pg.

6. Match the components in Column 2 to their functions in Column 1. Place a number from Column 2 opposite a letter in Column 1.

Column 1

a._____ Moves the airspeed pointer.

b._____ Is responsible for moving the mechanical linkage.

c._____ An airtight chamber where the sensing element is located.

d._____ Displays indicated airspeed against a dial calibrated in 10 knot increments.

e._____ Gives a quick accurate reading of "between the line" indications of the airspeed pointer.

Column 2

1. Aneroid.
2. Airspeed drum.
3. Indicator's case.
4. Airspeed pointer.
5. Mechanical linkage.
6. Airspeed diaphragm.

In summary, you must remember that the indicated airspeed section of the maximum allowable airspeed indicator uses pitot pressure (Pt) and static pressure (Ps). The sensing element, the airspeed diaphragm, measures a differential pressure that will operate the mechanical linkage. The mechanical linkage will move the airspeed pointer to provide a readout of indicated airspeed.

If you thoroughly understand the operation of the indicated airspeed section, proceed to frame 9 and begin the operation of the maximum allowable airspeed section.

If you do not understand the operation of the indicated airspeed section, request assistance from your instructor.

Answers to frame 7:

1. b. 2. a.

MAXIMUM ALLOWABLE AIRSPEED SECTION

Frame 9

The relationship of the aircraft's speed to the speed of sound is called mach. When the aircraft is traveling as fast as sound waves travel, the aircraft is flying at one mach. When the aircraft is flying half as fast as sound waves travel, the aircraft is traveling at .5 mach (five tenths). The aircraft's flight manual will state the maximum speed the aircraft may fly. This maximum speed is expressed in terms of mach and is called the critical mach number (M crit) of the aircraft. The critical mach number, or M crit, is the speed the aircraft may fly without experiencing structural damage or loss of control.

Circle the letter that identifies the correct answer.

1. The maximum speed the aircraft may fly without experiencing structural damage or loss of control is called

   a. M and is expressed in feet.

   b. M and is expressed in knots.

   c. M crit and is expressed in mach.

   d. M crit and is expressed in knots.

Answers to frame 8:

1. b. 2. c. 3. b. 4. c. 5. c.

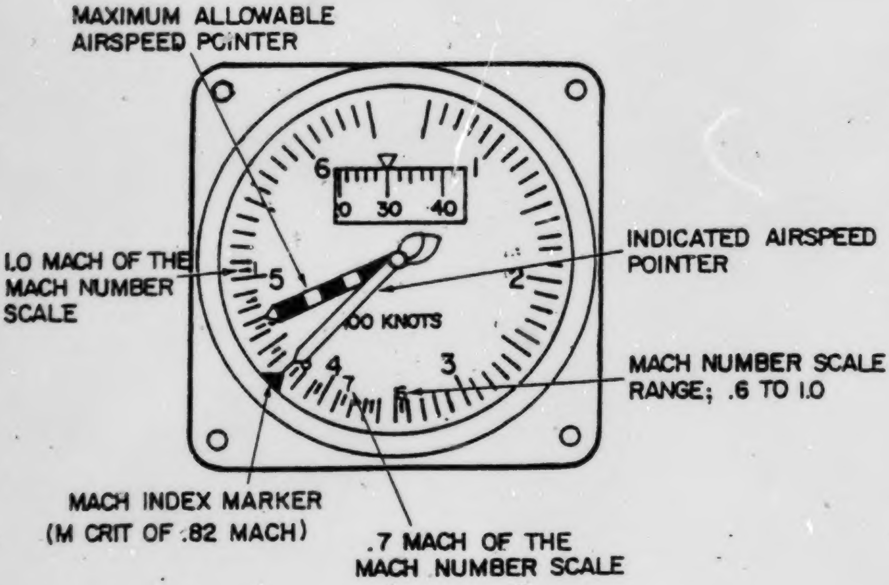
6. a __5__ b. __6__ c. __3__ d. __4__ e. __2__

Frame 10

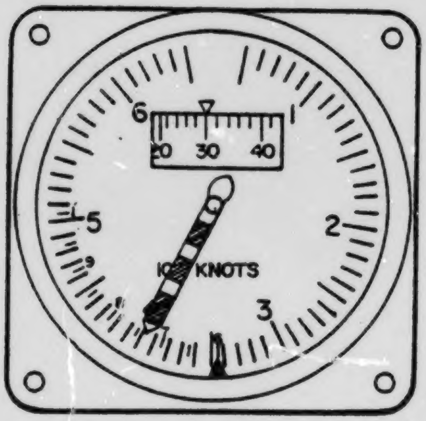
The Air Force uses the maximum allowable airspeed indicator in many different types of aircraft. These different types of aircraft have different M crits. For example, a jet bomber like the B-52 would have a higher M crit than a propeller driven C-130 cargo plane. The indicator has an adjustment that will allow the specialist to fit the indicator to a particular type of aircraft. This adjustment is called the mach number adjustment.

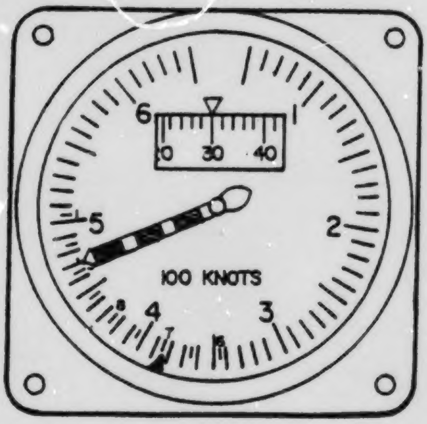
Before installing the indicator in the aircraft, the mach number adjustment must be set according to the tech order. Turning the adjustment screw causes the mach index marker to realign on the mach number scale. (See figure below.) When the M crit has been properly adjusted, the maximum allowable airspeed pointer will be displaying the M crit in knots. By displaying the M crit in knots, the pilot can compare his maximum allowable airspeed to his present indicated airspeed. The indicated airspeed pointer must never pass the maximum allowable pointer.

In the figure below, the maximum allowable airspeed pointer is positioned at 470 knots. The indicated airspeed pointer is displaying an airspeed of 430 knots. By comparing the pointers, it is easy to see that the pilot may go an additional 40 knots faster before he will have reached his maximum allowable airspeed.


MAXIMUM ALLOWABLE AIRSPEED POINTER
INDICATED AIRSPEED POINTER
1.0 MACH OF THE MACH NUMBER SCALE
MACH NUMBER SCALE RANGE; .6 TO 1.0
MACH INDEX MARKER (M CRIT OF .82 MACH)
.7 MACH OF THE MACH NUMBER SCALE
6
1
2
3
4
5
0
30
40
100 KNOTS

Read and record the position of the maximum allowable pointer and the mach index marker. Place your answers in the spaces provided.


6
1
20 30 40
5
2
100 KNOTS
3
9
8

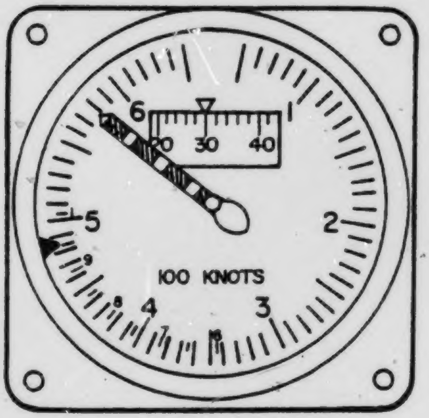

6
1
0 30 40
5
2
100 KNOTS
3
4
8
7
6

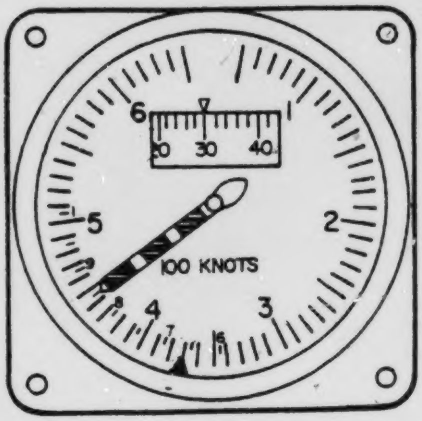
1. __________ knots

__________ mach

2. __________ knots

__________ mach


6
1
20 30 40
5
2
100 KNOTS
3
4
9
8
7
6


6
1
20 30 40
5
2
100 KNOTS
3
4
9
8
7
6

3. __________ knots

__________ mach

4. __________ knots

__________ mach

Circle the letter that identifies the correct answer.

1. What adjustment can be made to fit the maximum allowable airspeed indicator to different types of aircraft?

   a. The zero adjustment.

   b. The mach number adjustment.

   c. The airspeed pointer adjustment.

   d. The zero setting adjustment for the maximum allowable airspeed pointer.

2. The mach number adjustment screw is used to adjust the

   a. airspeed pointer.

   b. mach index marker.

   c. mach number scale.

   d. mach number scale and the airspeed pointer.

3. The mach index marker displays the aircraft's

   a. indicated airspeed.

   b. critical mach number.

   c. indicated mach number.

   d. maximum allowed speed in knots.

4. What is the range of the mach number scale?

   a. .4 mach to .8 mach.

   b. .6 mach to 1.0 mach.

   c. .8 mach to 1.2 mach.

   d. 1.0 mach to 1.4 mach.

5. How does the pilot determine when he has reached his maximum allowable airspeed?

   a. The copilot will tell him.

   b. The reduce speed light will come in.

   c. The pilot will radio to the ground and ask for a true airspeed reading from the radar technician.

   d. The pilot will compare the position of the indicated airspeed pointer to the position of the maximum allowable airspeed pointer.

6. The maximum speed the aircraft may fly without experiencing structural damage or loss of control is called

   a. M and is expressed in feet.

   b. M and is expressed in knots.

   c. M crit and is expressed in mach.

   d. M crit and is expressed in feet.

Answer to frame 9:

1. c.

Frame 11

As altitude increases to approximately 36,000 feet, the speed of sound decreases because the air gets colder and the sound waves do not travel through the air as fast. Therefore, the maximum allowable airspeed may change even when the M crit or critical mach number is held constant.

Example: If the M crit of an aircraft is .8 we would multiply the speed of sound at sea level times .8 to arrive at the maximum allowable airspeed the aircraft may fly at sea level.

662 knots (speed of sound at sea level)
x .8 mach (critical mach number)
529.6 knots, maximum allowable airspeed at sea level.

But, most aircraft don't fly at sea level. They fly at altitudes from a few hundred feet to many thousands of feet above sea level. An aircraft flying at 36,000 feet, is flying at an altitude where the speed of sound is only 575 knots. Therefore, if his M crit is .8 mach, then his maximum allowable airspeed would be 460 knots.

575 knots (speed of sound at 36,000 feet)
x .8 mach (critical mach number)
460.0 knots, maximum allowable airspeed at 36,000 feet.

The aircraft's maximum allowable airspeed at 36,000 feet is 70 knots less than the maximum allowable airspeed of an aircraft having an identical M crit but flying at sea level.

It would be extremely difficult for the pilot to figure the change in maximum allowable airspeed everytime the aircraft changes altitude.

To automatically figure any change in the aircraft's maximum allowable airspeed, the indicator has an aneroid that will expand as altitude increases. The expansion of the aneroid will move the maximum allowable pointer downscale as the altitude increases. With any decrease in altitude, the aneroid will contract causing the pointer to move back upscale.

Circle the letter that identifies the correct answer.

1. As altitude increases, the speed of sound will

   a. increase.

   b. decrease.

   c. remain the same.

2. As altitude increases, the maximum allowable airspeed pointer will move

   a. upscale.

   b. downscale.

   c. clockwise.

Answers to frame 10:

Indicator Readings:

1. 397 knots	2. 470 knots	3. 578 knots	4. 445 knots
.60 mach	.70 mach	.95 mach	.67 mach

Multiple choice questions:

1. b. 2. b. 3. b. 4. b. 5. d. 6. c

1147.

Frame 12

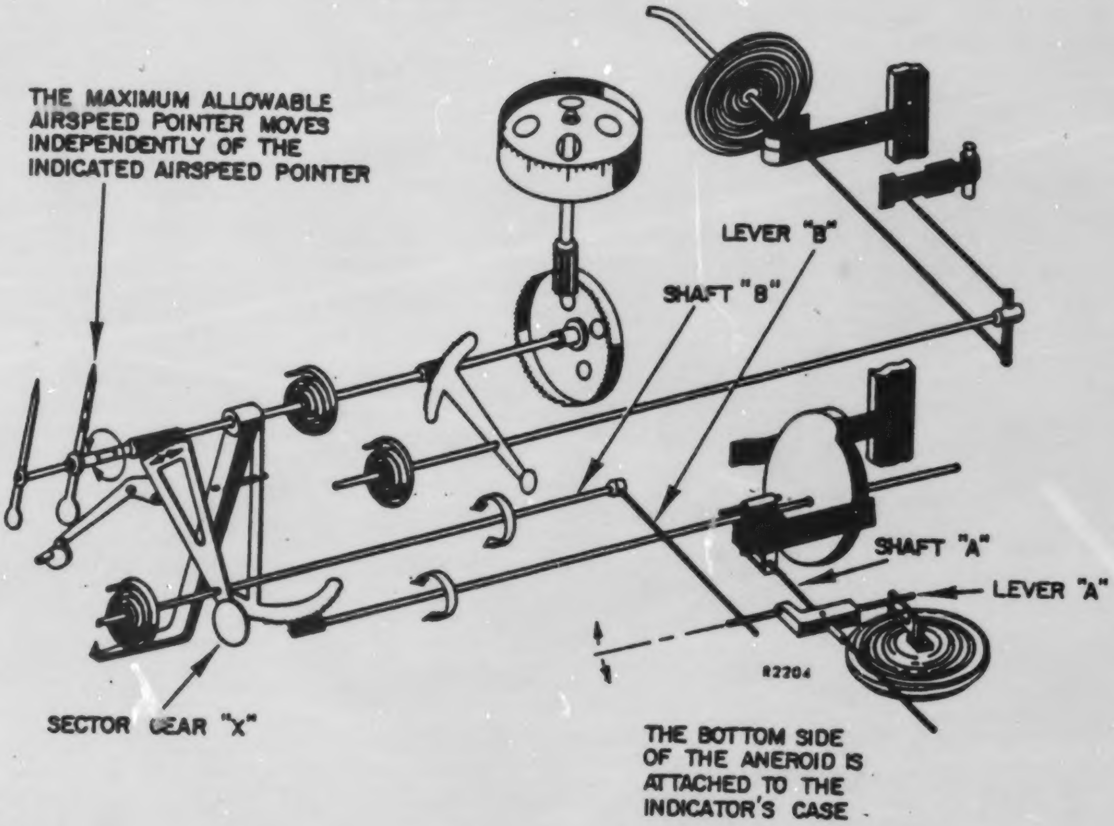
The steps listed below describe the movement of the components shown in the figure below.

Description of component movement:

1. The expansion or contraction of the aneroid will cause lever "A" to rotate about shaft "A".

2. The movement of lever "A" will cause lever "B" to move which will cause shaft "B" to rotate.

3. The rotation of shaft "B" will cause sector gear "X" to move causing the maximum allowable pointer to seek a new position.


THE MAXIMUM ALLOWABLE AIRSPEED POINTER MOVES INDEPENDENTLY OF THE INDICATED AIRSPEED POINTER
LEVER "B"
SHAFT "B"
SHAFT "A"
LEVER "A"
R2204
SECTOR GEAR "X"
THE BOTTOM SIDE OF THE ANEROID IS ATTACHED TO THE INDICATOR'S CASE

1179

Circle the letter that identifies the correct answer.

1. As Ps decreases, the aneroid will expand and cause

   a. sector gear "X" to move in a clockwise direction and the maximum allowable pointer to move downscale.

   b. sector gear "X" to move in a counterclockwise direction and the maximum allowable pointer to move downscale.

   c. sector gear "X" to move in a clockwise direction and the maximum allowable pointer to move upscale.

   d. sector gear "X" to move in a counterclockwise direction and the maximum allowable pointer to move upscale.

Answers to frame 11:

1. b. 2. b.

1149

Frame 13

The aneroid is responsible for computing the maximum allowable airspeed for any altitude the aircraft flies. Like the altimeter, the aneroid senses changes in static pressure and measures an absolute pressure. When the aneroid expands due to an increase in altitude, the maximum allowable pointer is driven downscale by the mechanical linkage connecting the aneroid to the pointer. As the aneroid contracts (gets smaller) due to a decrease in altitude, the pointer will move back upscale.

The purpose of the maximum allowable section of the indicator is to display the maximum allowable airspeed the aircraft may fly regardless of the altitude of the aircraft.

Circle the letter that identifies the correct answer.

1. What is the sensing element of the maximum allowable section of the indicator?

   a. Aneroid.

   b. Airspeed diaphragm.

   c. Differential mechanism.

   d. Differential diaphragm and a bellows.

2. What type of pressure is used and measured by the sensing element of the maximum allowable section?

   a. Uses Ps and measures impact pressure.

   b. Uses Pt and measures impact pressure.

   c. Uses Ps and measures absolute pressure.

   d. Uses Pt and measures absolute pressure.

3. What is the purpose of the maximum allowable section of the indicator?

   a. Displays true airspeed.

   b. Displays indicated airspeed.

   c. Displays calibrated airspeed.

   d. Displays maximum allowable airspeed.

1181

Answer to frame 12:

1. a.

Frame 14

We have determined that as altitude varies, the maximum allowable pointer moves because it is controlled by the aneroid. Sometimes it is necessary to decrease the maximum allowable airspeed even lower than what the aneroid will do automatically. The maximum allowable pointer adjustment screw is used for this purpose.

The maximum allowable pointer adjustment screw is located on the front of the indicator's case. This adjustment is used to adjust the maximum allowable pointer downscale to a lower starting point without changing the critical mach number setting. The aneroid will move the maximum allowable pointer downscale from the new starting point with any increase in altitude. This adjustment may be necessary due to the addition of bombs, rockets, or wing tanks which change the structural limitations of the aircraft. This adjustment can be made by the pilot or crew chief of the aircraft. When the aircraft is back to normal load conditions, the pointer adjustment may be used to return the maximum allowable pointer to its normal position.

Circle the letter that identifies the correct answer.

1. The maximum allowable pointer is adjusted due to changes in the

   a. mach number setting.

   b. pilots of the aircraft.

   c. indicated airspeed indications.

   d. structural limitations of the aircraft.

Answers to frame 13:

1. a. 2. c. 3. d

Frame 15

The inspection procedures vary from aircraft to aircraft. YOU MUST ALWAYS refer to the technical order for the aircraft you are working on. In general, the following checks must be performed.

1. Check for security of mounting.

2. Check the lines for proper connections and tightness.

3. Check the condition of the cover glass, the range marks, and the slippage mark.

4. Check the M crit setting and the maximum allowable pointer setting according to the TO for the aircraft.

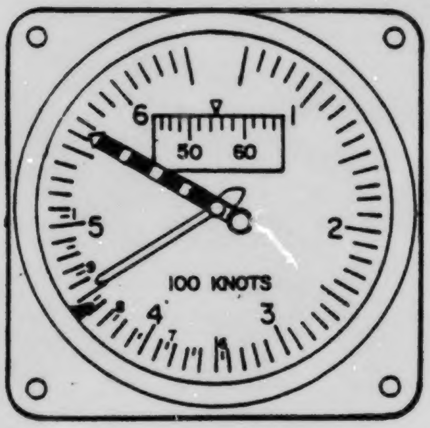
NO RESPONSE REQUIRED.

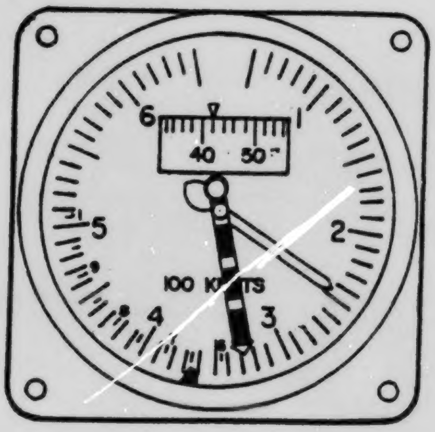
Answer to frame 14:

1. d.

Frame 16

Read and record the position of the indicated airspeed pointer, the mach index marker, and the maximum allowable airspeed pointer. Place your answers in the spaces provided.





1. __________ knots (indicated airspeed)

__________ mach (critical mach number)

__________ knots (maximum allowable airspeed)

2. __________ knots (indicated airspeed)

__________ mach (critical mach number)

__________ knots (maximum allowable airspeed)

(Reference: Frame 3 and Frame 10)

Frame 17

You have studied the pitot-static system and 3 indicators, the altimeter, the vertical velocity indicator, and the maximum allowable airspeed indicator. It is essential that you understand the following subject areas that were previously discussed.

1. The purpose of the pitot-static system and each indicator.

2. The definition of pitot pressure, static pressure and impact pressure.

3. The purpose of the pitot-static probe and its component parts.

4. How to read each indicator.

5. The sensing elements used by each indicator.

6. The pressures used and measured by each indicator.

7. The function of the component parts of each indicator.

If you are not sure of any of the above subject areas, review the material and ask your instructor for help when necessary.

Next we are going to discuss one piece of test equipment used to perform an operational check of the pitot-static system.

NO RESPONSE REQUIRED

Part I
Section E
MB-1 PITOT-STATIC FIELD TESTER

Frame 1

The MB-1 pitot static field tester is used to leak check and operationally check the pitot static system. The tester is a portable unit enclosed in a metal carrying case. It consists of hand operated pressure and vacuum pumps, pressure and vacuum gages, five control valves, and altimeter, airspeed indicator, and a thermometer.

Check (✓) the correct answer(s) below in the space provided.

1. The purpose of the MB-1 field tester is to

_____a. leak check and operational check the pitot static system.

_____b. apply vacuum only to the pitot static system.

_____c. apply vacuum and pressure for a leak check only.

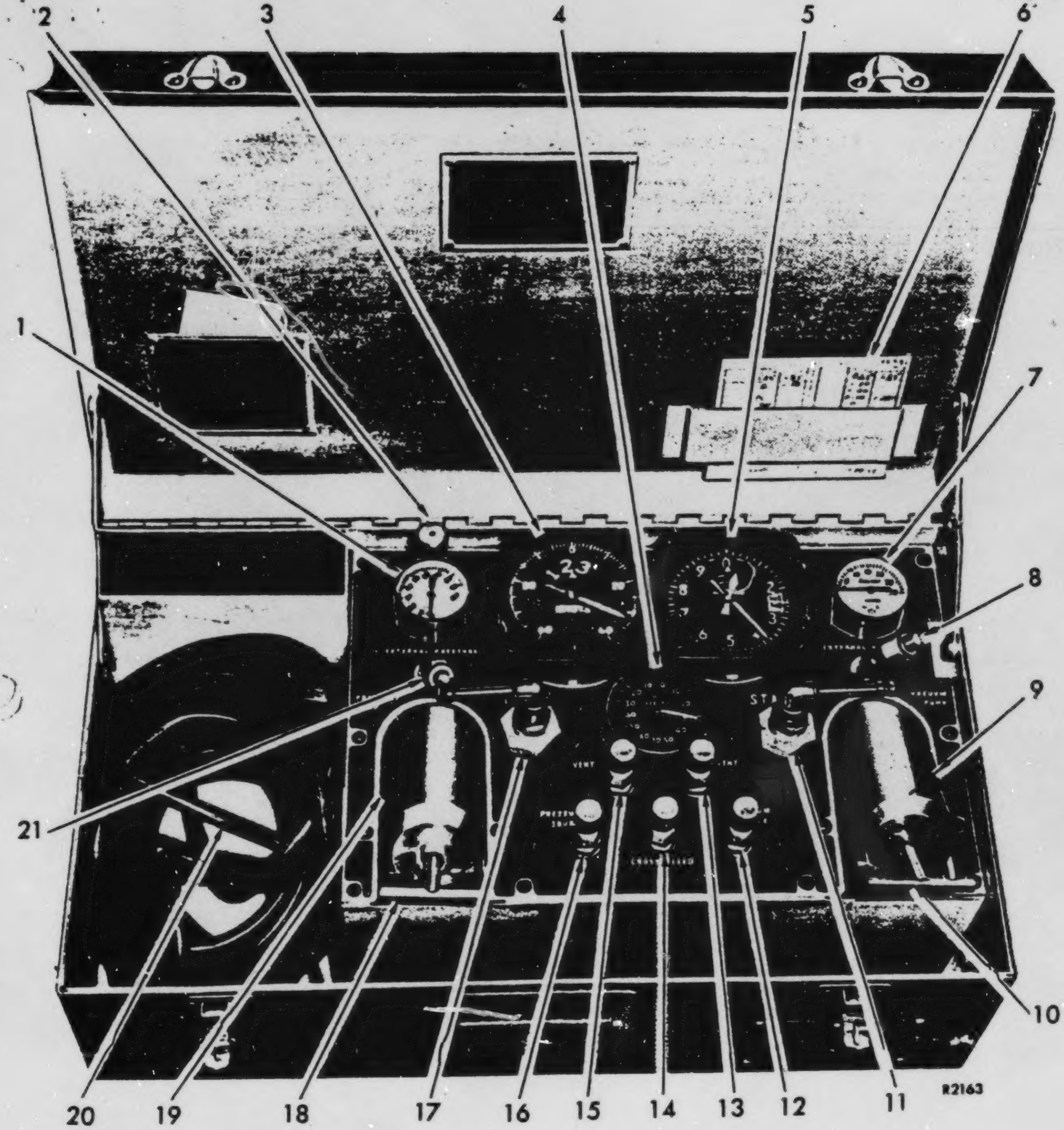
Frame 2

The pressure side of the MB-1 field tester is illustrated in figure 1. It consists of a pressure pump (18), pressure gage (1), pitot pressure hose connection (17), external pressure connection (21), pressure source valve (16), pressure vent valve (15), and a cross bleed valve (14).

NO RESPONSE REQUIRED

Answer to Frame 1:

__✓__ a.



1 PRESSURE GAGE
2 PRESSURE RELIEF VALVE
3 AIRSPEED INDICATOR
4 THERMOMETER
5 ALTIMETER
6 INSTRUMENT CALIBRATION CARDS
7 VACUUM GAGE

8 EXTERNAL VACUUM CONNECTION
9 VACUUM PUMP
10 VACUUM-TANK HAND-OPERATED PUMP
11 STATIC HOSE CONNECTION
12 VACUUM SOURCE VALVE
13 VACUUM VENT VALVE
14 CROSS-BLEED VALVE

15 PRESSURE VENT VALVE
16 PRESSURE SOURCE VALVE
17 PITOT HOSE CONNECTION
18 PRESSURE TANK HAND-OPERATED PUMP
19 PRESSURE PUMP
20 PITOT AND STATIC RUBBER HOSES
21 EXTERNAL PRESSURE CONNECTION

Figure 1.

Frame 3

The pressure pump (18) in figure 1 is used to supply pressure to the tester. The amount of pressure in the tester is indicated on the pressure gage (1) in inches of mercury. The pressure pump can be bypassed if a pressure source is connected into the external pressure connection (21). Pressure can be applied to the pitot system by opening the pressure source valve (16). Pressure is released from the system by opening the pressure vent valve (15). Pressure can also be released by venting the pressure into the static side of the MB-1 by using the cross bleed valve (14).

Match the following components in column B to their functions in column A by writing the correct letter in the spaces provided.

A

_____1. Indicates amount of pressure in tester.

_____2. Supplied pressure for the MB-1.

_____3. Hookup for external pressure into the MB-1.

_____4. Admits pressure from the tank into the system.

_____5. Releases pressure from the system.

_____6. Bleeds pressure into the static side of the MB-1.

B

a. External pressure connection.

b. Pressure source valve.

c. Pressure vent valve.

d. Pressure pump.

e. Cross bleed valve.

f. Pressure gage.

Answer to frame 2:

No response required.

Frame 4

The static side of the MB-1 pitot-static field tester is shown in figure 2. It consists of a vacuum pump (1), vacuum gage (2), external vacuum connection (3), vacuum source valve (4), vacuum vent valve (5), and a cross bleed valve (6) used in common with the pressure side of the tester.

Note: The cross bleed valve will not be used at any time during the operational check.

NO RESPONSE REQUIRED

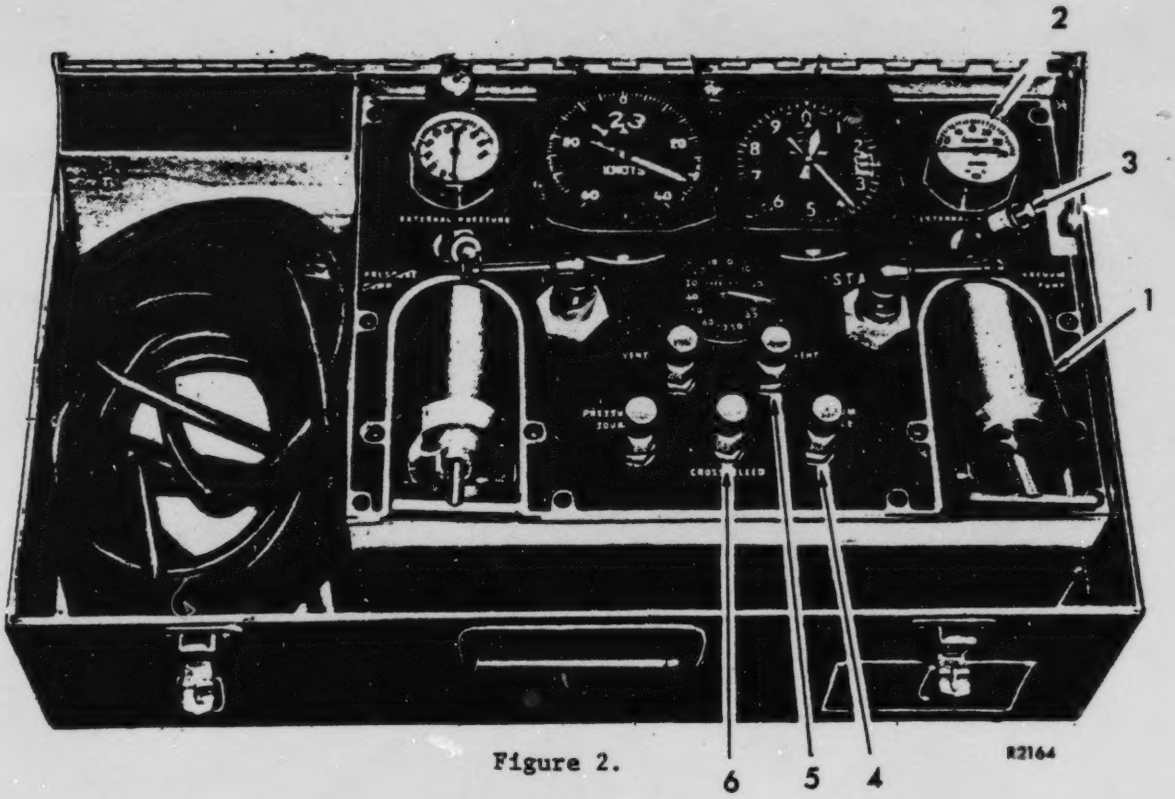

2
3
1
EXTERNAL PRESSURE
KNOTS
VENT
CROSS BLEED
6
5
4
R2164

Figure 2.

Answers to frame 3:

1. f 2. d 3. a 4. b 5. c 6. e

Frame 5

The vacuum pump (1) is used to supply vacuum to the MB-1 pitot-static field tester. The amount of vacuum is indicated on the vacuum gage. If an external vacuum source is available, the vacuum pump may be bypassed by connecting a vacuum source to the external vacuum connection. The vacuum in the MB-1 can be applied to the pitot static system by opening the vacuum source valve. Vacuum can be released from the system by opening the vacuum vent valve. The vacuum can also be bled into the pressure side of the tester by using the cross-bleed valve.

Match the following components in column B to their functions in column A, by writing the correct letter in the spaces provided.

A	B
_____1. Used to supply vacuum to the tester.	a. Vacuum pump
_____2. Releases vacuum from the static system.	b. Vacuum gage
_____3. Indicates the amount of vacuum in the MB-1 tester.	c. External vacuum connection
_____4. Bleeds vacuum to the pressure side of the MB-1.	d. Vacuum source valve
_____5. Admits vacuum into the system.	e. Vacuum vent valve
_____6. Hookup for external vacuum pressure.	f. Cross-bleed valve

Answer to frame 4:

No response required.

The airspeed indicator, altimeter, and thermometer that are used on the MB-1 are shown in the upper center of the figure below. The airspeed indicator indicates the amount of pitot pressure in knots. The altimeter is used to indicate the amount of vacuum pressure in feet. The thermometer is used to indicate the ambient temperature in degrees Celsius. The temperature must be used when computing true airspeed and when checking a true airspeed indicator.

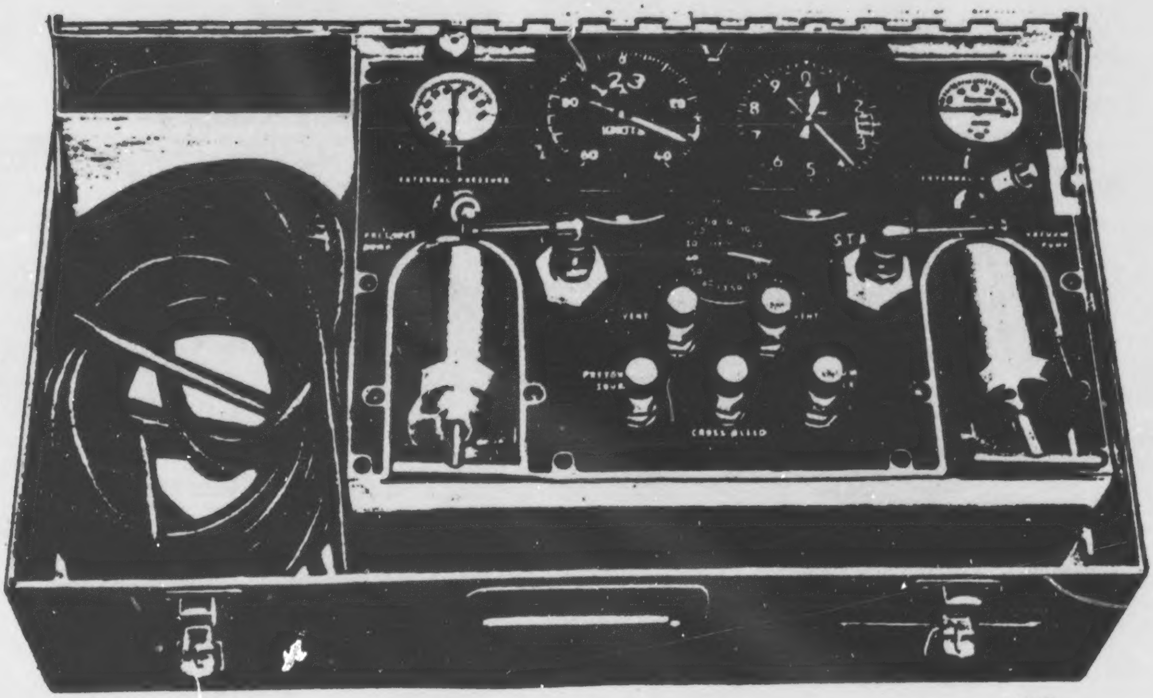


Figure 3.

R2165

Using figure 3, match the following components in column B with their functions in column A, by writing the correct letter in the spaces provided.

	A		B
____1.	Indicates ambient temperature in °C.	a.	Altimeter
____2.	Indicates pressure in knots.	b.	Airspeed indicator
____3.	Indicates vacuum in feet.	c.	Thermometer

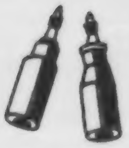
Answers to frame 5

1. __a__ 2. __e__ 3. __b__ 4. __f__ 5. __d__ 6. __c__

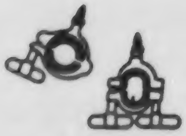
Frame 7

Using the hose and adapters supplied with the MB-1 pitot-static field tester, the tester can be adapted for use on any aircraft. The rubber adapters in the A portion of the figure below transfer pitot pressure from the tester into the aircraft pitot static system. The adapters in the B portion of the figure are used to transfer the static pressure in the tester to the aircraft static system.

NO RESPONSE REQUIRED



A



B

Answers to frame 6:

1. __c__ 2. __b__ 3. __a__

After completing an appraisal covering this material, proceed to the lab to perform an operational check of the pitot-static system, troubleshoot the pitot-static system, and bench check a vertical velocity indicator, an altimeter, and a maximum allowable airspeed indicator.

Part II

Sections A, B and C

Part II of this text covers three (3) more indicators that utilize the pitot-static system for their operation. They are the standby airspeed indicator, the true airspeed indicator, and the transonic machmeter. Each indicator meets the specific design requirements of the aircraft that utilize them.

After completing this text you should know the following information about each indicator:

1. The purpose.
2. The type of pressure or pressures it uses.
3. The sensing element.
4. The function of its component parts.
5. How to read it.

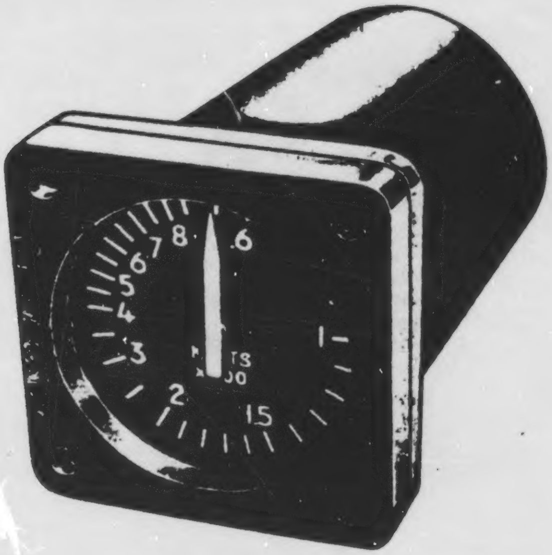
NO RESPONSE REQUIRED

1163

Part II
Section A
STANDBY AIRSPEED INDICATOR

Frame 1

The first indicator that we will discuss is the standby airspeed indicator with a range of 60 to 850 knots. In aircraft of modern design the Air Force uses a variety of different types of airspeed indicators. They all basically operate the same. The airspeed indicator is a differential pressure measuring device. This differential is caused by the difference between pitot pressure and static pressure.



Check the correct response(s) below.

_____a. The Air Force uses only one type of airspeed indicator.

_____b. The airspeed indicator is a differential pressure measuring device.

_____c. Pitot pressure is the only pressure used.

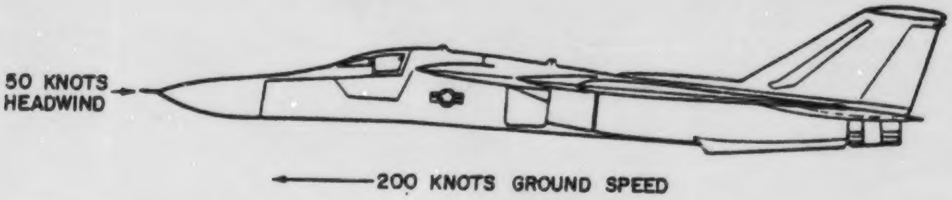
1195

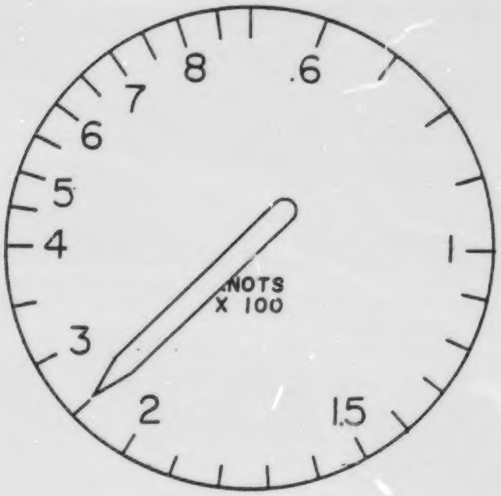
Answers to Frame 1: _____a. __✓__b. _____c.

Frame 2

The standby airspeed indicator measures the speed of the air passing over the wings of the aircraft and is not to be confused with ground speed. An example would be as follows, if an aircraft was flying at a ground speed of 200 knots with a tail wind of 50 knots, the indicator would read 150 knots. The opposite would be an aircraft flying at a ground speed of 200 knots with a head wind of 50 knots, the indicator would indicate 250 knots.

The standby indicator does not make any corrections for temperature and altitude changes.





Check the correct response(s) below.

_____a. The airspeed indicator indicates ground speed.

_____b. An aircraft with a tail wind would add the speed of the wind to get the correct indication on the indicator.

_____c. A ground speed of 350 knots and a head wind of 40 knots will cause the indicator to read 390 knots.

Answers to Frame 2: _____a. _____b. __✓__c.

Frame 3

Pitot and static pressure will always be equal when the aircraft is at rest and no wind is blowing. But when the aircraft is in flight, pitot pressure will exceed static pressure. The difference between these two pressures is proportional to the aircraft's speed. Therefore, the faster the aircraft moves, the pitot pressure increases with respect to static pressure causing a higher reading on the indicator. With a decrease in airspeed, pitot pressure decreases and the airspeed indicator shows a decrease. Also, with an increase in altitude there is a decrease in pitot pressure due to the fact that the air density decreases with altitude.

Check the correct response(s) below.

_____a. Pitot and static pressure are equal when the aircraft is in flight.

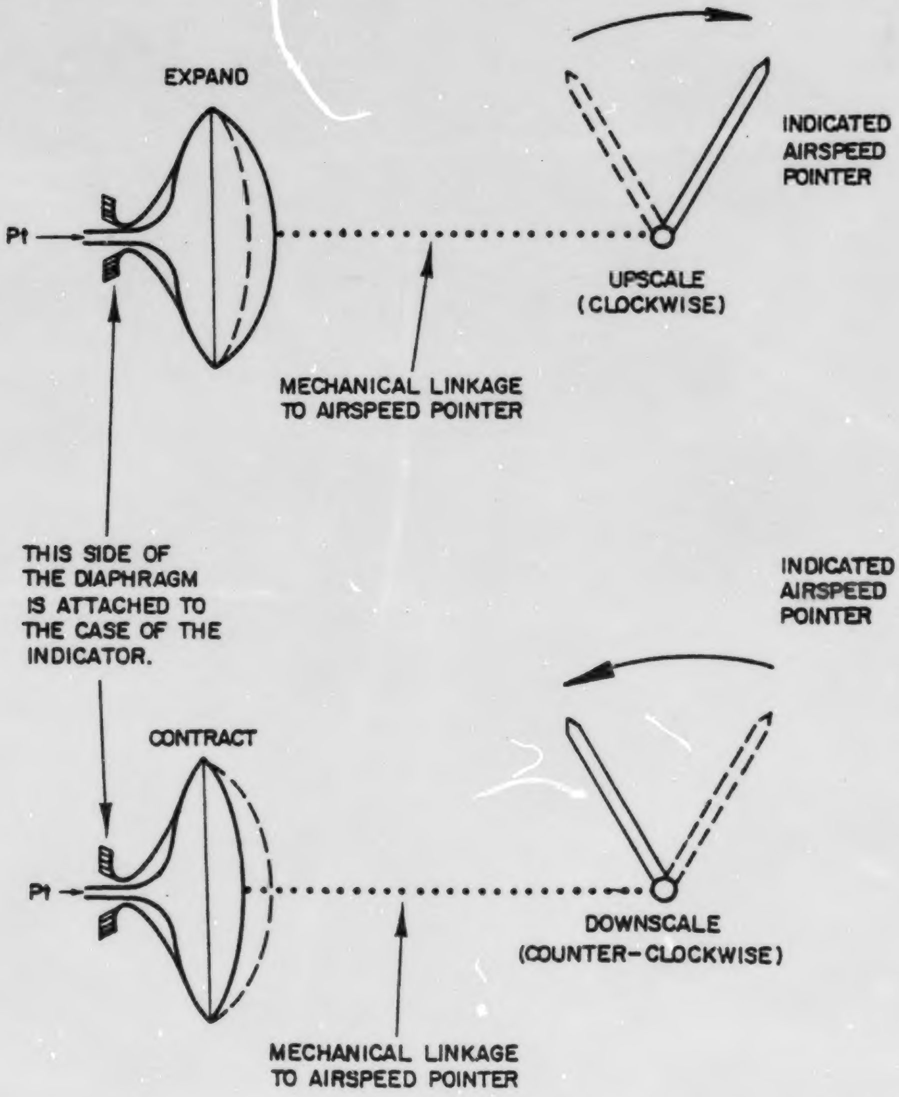
_____b. The difference between pitot pressure and static pressure is proportional to the speed of the aircraft.

_____c. Pitot pressure decreases with an increase in altitude.

Answers to Frame 3: ____a. __✓__b. __✓__c.

Frame 4

Pitot pressure is fed directly to a diaphragm within the airspeed indicator. Static pressure is fed to the inside of the case of the indicator to surround the diaphragm. As pitot pressure increases, the diaphragm expands, causing the mechanical linkage to move, thus showing an indication on the pointer of the airspeed indicator.


EXPAND
Pt
INDICATED AIRSPEED POINTER
UPSCALE (CLOCKWISE)
MECHANICAL LINKAGE TO AIRSPEED POINTER
THIS SIDE OF THE DIAPHRAGM IS ATTACHED TO THE CASE OF THE INDICATOR.
INDICATED AIRSPEED POINTER
CONTRACT
Pt
DOWNSCALE (COUNTER-CLOCKWISE)
MECHANICAL LINKAGE TO AIRSPEED POINTER

Check the correct response(s) below.

_____a. Pitot pressure is fed to the inside of the case to surround the diaphragm.

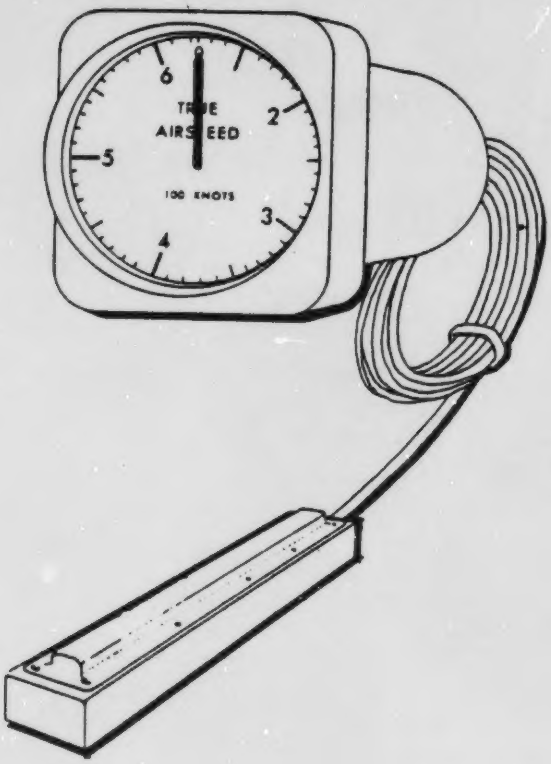
_____b. As pitot pressure increases, the diaphragm expands, thus causing the pointer to indicate an increase in airspeed.

Answer to Frame 4: ____ a. __✓__ b.

Part II
Section B
TRUE AIRSPEED INDICATOR

Frame 1

The True Airspeed Indicator, shown below, is designed to indicate the airspeed of the aircraft with corrections for temperature and altitude changes. With these corrections, the True Airspeed Indicator indicates the actual speed of the air moving across the aircraft. Without these corrections, the indicator would give incorrect airspeed indications at different temperatures and altitudes. This problem occurs because the density of air changes according to air temperature and altitude.



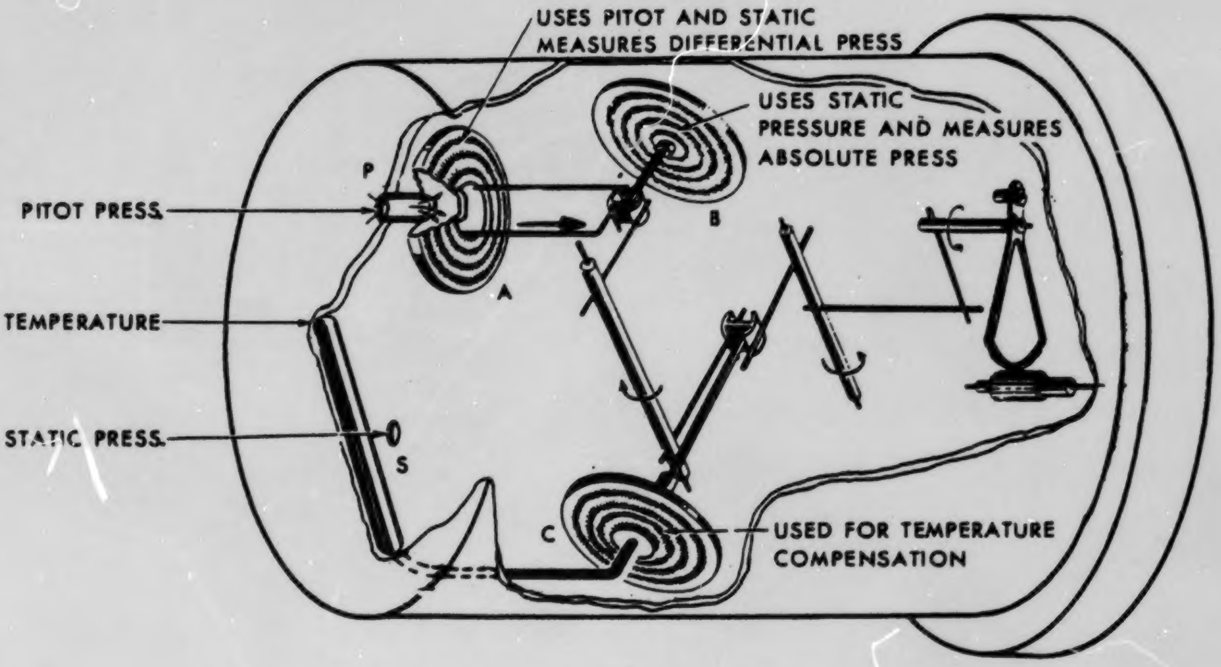
Circle the letter that identifies the true statement(s).

a. The True Airspeed Indicator compensates for altitude changes only.

b. The True Airspeed Indicator indicates the airspeed of the aircraft with corrections for temperature and altitude changes.

c. The True Airspeed Indicator is designed to indicate the ground speed of the aircraft.

d. The amount of air changes with a change in temperature and altitude.


USES PITOT AND STATIC
MEASURES DIFFERENTIAL PRESS
USES STATIC
PRESSURE AND MEASURES
ABSOLUTE PRESS
P
PITOT PRESS
B
A
TEMPERATURE
STATIC PRESS
S
C
USED FOR TEMPERATURE
COMPENSATION

The True Airspeed Indicator, like all other airspeed indicators, uses pitot-static pressures supplied by the pitot-static system. Pitot pressure is applied to the back of the airspeed indicator through an opening marked P for pitot. This pressure is applied to the inside of one of the three sensing elements shown in the figure above (diaphragm A). This sensing element, diaphragm A, uses pitot pressure and measures differential pressure. Aneroid B is surrounded by static pressure which is applied to the indicator through an opening marked S for static pressure. This sensing element, aneroid B, uses static pressure and measures absolute pressure.

Circle the letter that indicates the correct answer to the questions below.

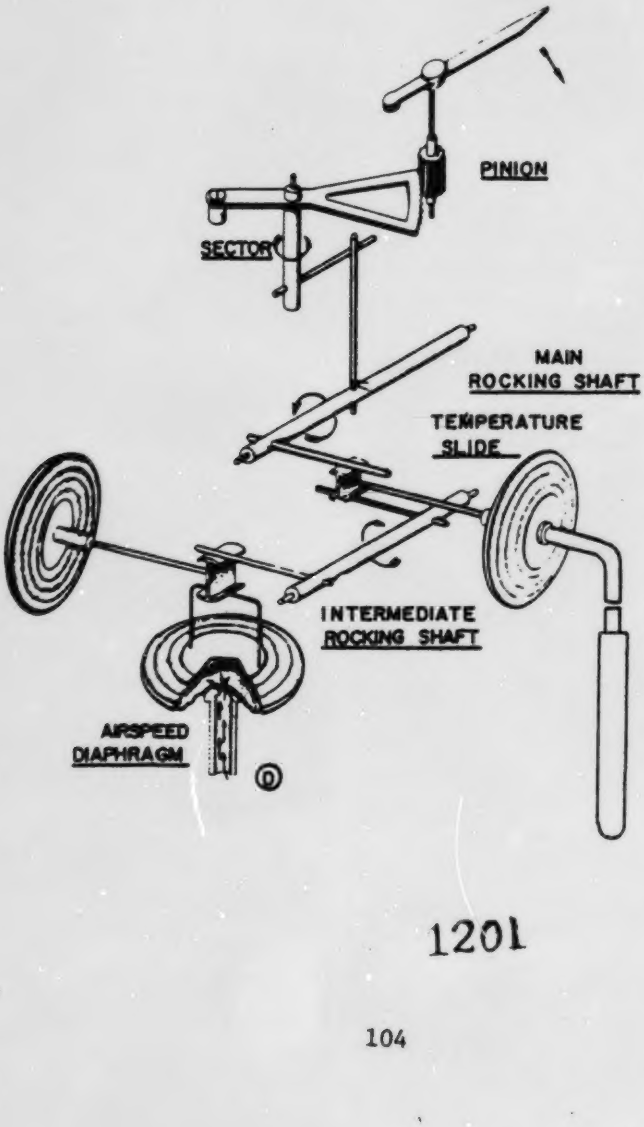
1. What pressure(s) is (are) used by the True Airspeed Indicator?
   - a. Pitot only.
   - b. Static only.
   - c. Pitot and static.
   - d. Pitot, static, and differential.

2. What pressures are measured by the True Airspeed Indicator?
   - a. Pitot and static.
   - b. Pitot and differential.
   - c. Differential and static.
   - d. Differential and absolute.

Answers to Frame 1: b

Frame 3

The True Airspeed Indicator has three sensing elements contained inside an airtight case. Static pressure surrounds all three of these sensing elements. The first sensing element is an airspeed diaphragm D shown in the figure below. An airspeed diaphragm consists of two thin discs of berryllium copper soldered together with an inlet for pitot pressure. The function of the airspeed diaphragm is to expand or contract because of the difference between pressure inside the diaphragm (pitot) and pressure outside the diaphragm (static). The difference between pitot and static pressure is impact pressure. In order to have a change in impact pressure, one of the following changes must occur: a change in speed, a change in altitude, a change in air temperature, or any combination of the three. Any of these changes will cause the airspeed diaphragm to expand or contract.


PINION
SECTOR
MAIN ROCKING SHAFT
TEMPERATURE SLIDE
INTERMEDIATE ROCKING SHAFT
AIRSPEED DIAPHRAGM
D

1201

Check (✓) the correct statement(s).

_____a. The True Airspeed Indicator has three sensing elements.

_____b. The airspeed diaphragm has pitot pressure on the outside of it.

_____c. The airspeed diaphragm will expand or contract with a change in impact pressure.

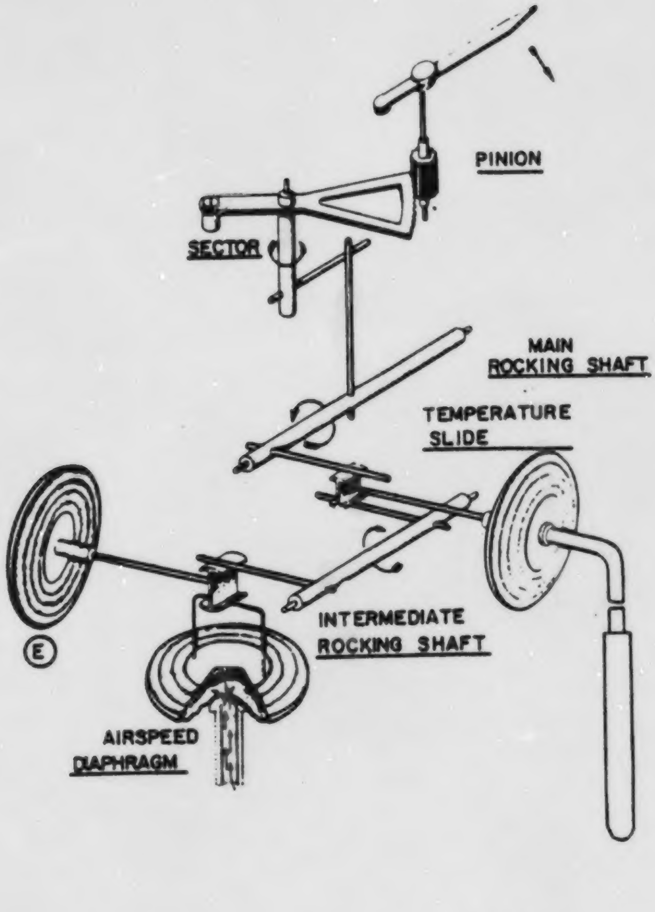
_____d. The airspeed diaphragm will contract with a decrease in altitude.

Answers to Frame 2: 1. c 2. d

1171

Frame 4

The second sensing element of the True Airspeed Indicator is the aneroid E, also called the altitude diaphragm. (Refer to the figure below.) Its construction is similar to the airspeed diaphragm with the exception that the aneroid is evacuated and sealed. Expansion and contraction is caused by a change in the static pressure surrounding the aneroid. A decrease in static pressure (increase in altitude) will cause the aneroid to expand. An increase in static pressure (decrease in altitude) will cause the aneroid to contract. The aneroid is used to compensate for the movement of the airspeed diaphragm due to a change in altitude. When the airspeed diaphragm expands because of the aircraft encountering more impact pressure at a lower altitude, the aneroid will contract. The movement of the aneroid will compensate for the movement of the airspeed diaphragm resulting in NO pointer movement due to a change in altitude.



1203

Check (✓) the correct statement(s).

_____a. An aneroid is the second sensing element of the True Airspeed Indicator.

_____b. The aneroid expands with a decrease in altitude.

_____c. The aneroid expands with a change in airspeed.

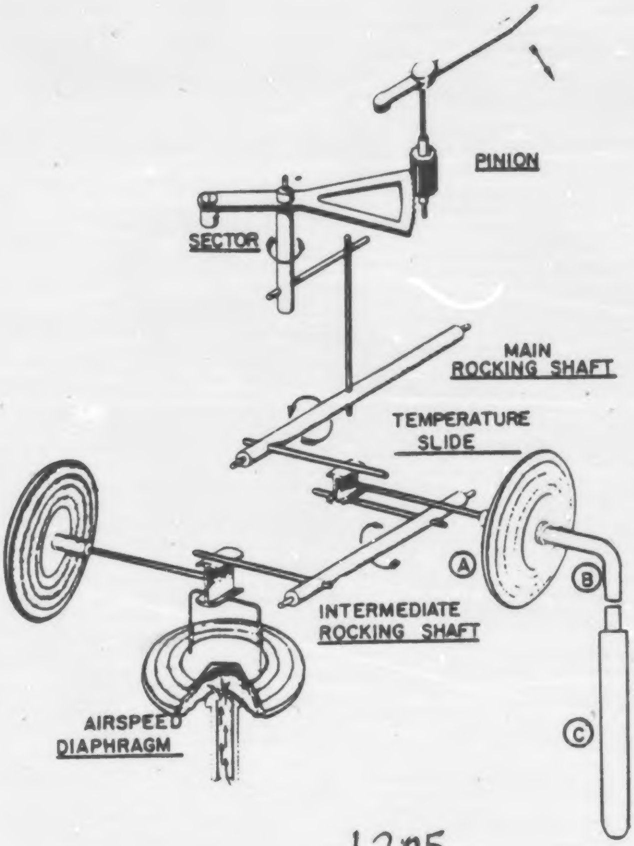
_____d. The aneroid prevents pointer movement due to an altitude change.

Answers to Frame 3: a, c

Frame 5

The third sensing element is a temperature diaphragm A as shown below. It is designed like the airspeed diaphragm; instead of pitot pressure on the inside, a gas pressure from a temperature bulb is applied to the inside of the temperature diaphragm. Expansion or contraction of the temperature diaphragm will compensate for the movement of the airspeed diaphragm due to a change in air temperature.

The flush mounted temperature bulb C contains a substance called methyl chloride which is very sensitive to any temperature change. It changes from a liquid state to a gas with an increase in temperature and from a gas back to a liquid with a decrease in temperature. There will always be some liquid and some gas in the bulb regardless of the outside temperature. The change in gas pressure is applied to the temperature diaphragm through capillary tubing B which connects the temperature bulb to the temperature diaphragm. As the air temperature changes, the temperature diaphragm expands or contracts due to a change in gas pressure. The movement of the temperature diaphragm will compensate for any movement of the airspeed diaphragm due to a change in air temperature.



Check (✓) the true statement(s).

_____a. The temperature diaphragm compensates for movement of the airspeed diaphragm due to a change in air temperature.

_____b. The substance, methyl chloride, is used to sense a change in air temperature.

_____c. The substance, methyl chloride, causes the airspeed diaphragm to expand.

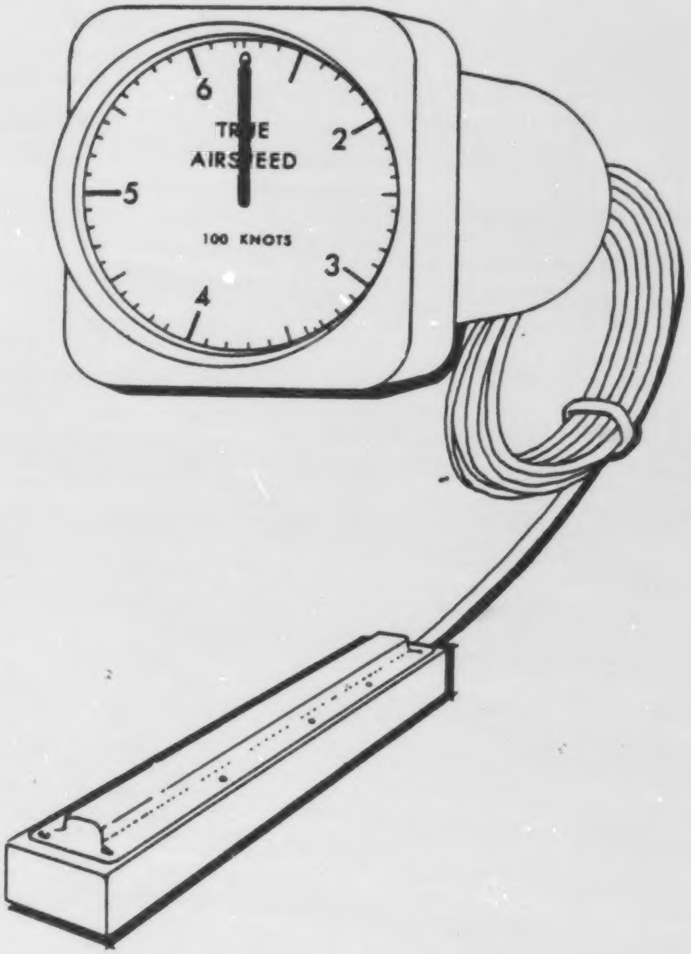
_____d. The temperature bulb is connected to the aneroid by means of capillary tubing.

Answers to Frame 4: a, d

1175

Frame 6

The dial face of the True Airspeed Indicator reads in knots. Knots are referenced to nautical miles instead of statute miles (miles per hour). The range of the True Airspeed Indicator is 150 knots to 600 knots. Even though a "0" mark is on the dial face, the instrument will show no indication less than 150 knots. The dial is graduated in 10-knot increments as shown in the picture of the True Airspeed Indicator below.



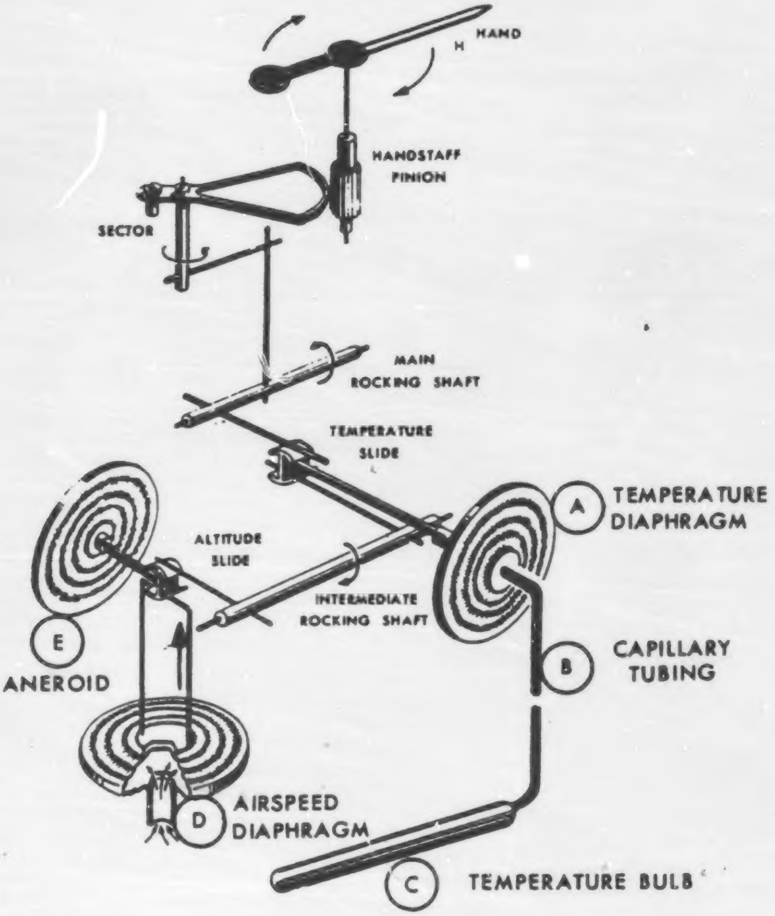
NO RESPONSE REQUIRED

Answers to Frame 5: a, b

1207

Frame 7

Using the drawing below, match the letters of the components with the purpose of the components listed below.


HAND
H
HANDSTAFF PINION
SECTOR
MAIN ROCKING SHAFT
TEMPERATURE SLIDE
A TEMPERATURE DIAPHRAGM
ALTITUDE SLIDE
INTERMEDIATE ROCKING SHAFT
E
ANEROID
B CAPILLARY TUBING
D AIRSPEED DIAPHRAGM
C TEMPERATURE BULB

_____1. Provides a path for methyl chloride gas.

_____2. Measures differential pressure.

_____3. Senses changes in air temperature.

_____4. Compensates for changes in altitude on the airspeed diaphragm.

_____5. Expands with an increase in temperature.

Frame 8

Now let's review the material covered to this point. The purpose of the True Airspeed Indicator is to indicate the airspeed of the aircraft with corrections for temperature and altitude changes. The True Airspeed Indicator uses pitot and static pressures and measures differential and absolute pressures. The True Airspeed Indicator contains three sensing elements: airspeed diaphragm, aneroid (altitude diaphragm), and temperature diaphragm. The airspeed diaphragm will expand or contract with any change in impact pressure. The aneroid will compensate for any change in altitude that affects the airspeed diaphragm. The temperature compensating unit, which consists of the temperature diaphragm, temperature bulb, and capillary tubing, compensates for changes in ambient air temperature that would affect the airspeed diaphragm. The movement of the airspeed diaphragm will affect the pointer shaft only if there is an actual change in airspeed.

NO RESPONSE REQUIRED

Answers to Frame 7: 1. b 2. D 3. C 4. E 5. A

Part II
Section C
TRANSONIC MACHMETER

Frame 1

The transonic machmeter is used on aircraft capable of approaching and exceeding the speed of sound.

High performance aircraft are often redlined (limited) by Mach number as well as airspeed. For instance, the handbook of Flight Operating Instructions for one type of aircraft may contain instructions to the effect that "the speed of the aircraft should not exceed 550 knots or Mach 0.89, whichever occurs sooner." Therefore, many jet aircraft are equipped with both an airspeed indicator and a machmeter. Mach number is pronounced "mock number." It is defined as a number representing the ratio of the aircraft's true airspeed to the speed of sound in the surrounding atmosphere.

The transonic machmeter serves to remind the pilot not to exceed the structural limits of his aircraft. This means that the pilot should not fly the aircraft faster than it is designed (red line on instrument face) to fly. If the Mach limit of the aircraft is exceeded, structural damage might occur causing the aircraft to crash.

Circle the letter that identifies the correct answer.

1. Mach number is defined as

   a. a number representing the speed of sound.

   b. the speed of sound at any altitude.

   c. the ratio of the aircraft's true airspeed to the speed of sound.

   d. the ratio between the aircraft's airspeed and ground speed.

1179

Frame 2

Mach 1 means that the aircraft's airspeed is equal to the speed of sound. The speed of sound at sea level, on a normal day, is 662 knots. It decreases with an increase in altitude. At 36,200' the speed of sound is 573.3 knots and remains constant until an altitude of 65,600' is reached. Temperature is the primary factor which causes the speed of sound to decrease when altitude is increased. The speed of sound is directly proportional to a change in temperature.

Circle the letters that identify the correct answers to each of the statements below.

1. If the aircraft is flying at the speed of sound, the Mach number would be

   a. .1

   b. .5

   c. 1.0

   d. 1.5

2. The primary factor affecting the change in the speed of sound is a change in

   a. Mach.

   b. altitude.

   c. temperature.

   d. pressure.

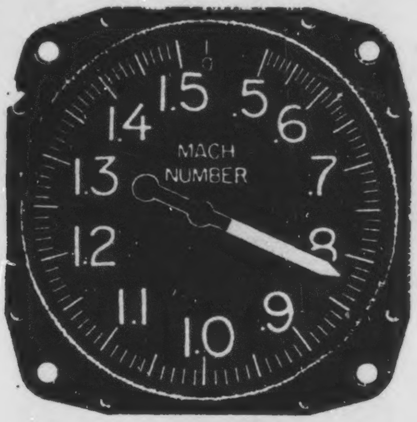
Answer to Frame 1:

1. c

1211

Frame 3

The dial range of the Transonic Machmeter is calibrated from .5 to 1.5 Mach. (The small "zero" is used only for bench calibration purposes and is not part of the range.) A reading of .5 Mach is 50% of the speed of sound (aircraft's airspeed in relation to the speed of sound.) Likewise, .9 Mach is 90% of the speed of sound. The purpose of this instrument is to indicate the aircraft's true airspeed in relation to the speed of sound at any altitude. The pointer on the machmeter, shown, is indicating .825 Mach. This means the aircraft's speed is almost 83% of the speed of sound.



Circle the letters that identify the correct answers below.

1. The calibrated Mach number range of the Transonic Machmeter is

   a. 0 to 1.0 Mach.

   b. 0 to 1.5 Mach.

   c. .5 to 1.0 Mach.

   d. .5 to 1.5 Mach.

2. The machmeter is designed to indicate the

   a. speed of sound up to 50,000'.

   b. speed of sound at all altitudes.

   c. airspeed of the aircraft in knots.

   d. aircraft's true airspeed in relation to the speed of sound.

Answers to Frame 2:

1. c 2. c

1181.

Frame 4

The sensing elements used by the machmeter are an airspeed diaphragm and an altitude diaphragm (aneroid). The airspeed diaphragm uses both pitot and static pressure. It measures the difference between these pressures. Therefore, the airspeed diaphragm measures differential pressure. For greater sensitivity, stacked airspeed diaphragms and aneroids are used in the machmeters.

Circle the letter(s) of the correct statement(s) below.

1. The airspeed diaphragm

   a. uses pitot pressure only.

   b. measures differential pressure.

   c. uses pitot and static pressure.

   d. uses static pressure and measures absolute.

Answers to Frame 3:

1. d 2. d

1213

The aneroid use static pressure only and measure absolute pressure. The aneroid expands when the aircraft increases altitude and contracts with a decrease in altitude.

Circle the letter(s) of the correct statement(s) below.

1. The purpose of the aneroid assembly is to

   a. expand when altitude decreases.

   b. compensate for the speed of sound.

   c. expand when altitude increases.

   d. correct for case temperature changes.

2. The Transonic Machmeter

   a. uses pitot and static pressure and measures differential pressure.

   b. uses static pressure and measures absolute pressure.

   c. indicates the speed of sound.

   d. indicates the aircraft's true airspeed.

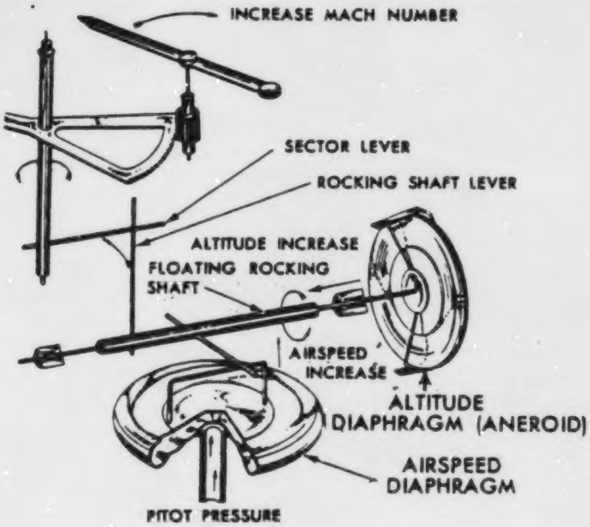
Answers to Frame 4:

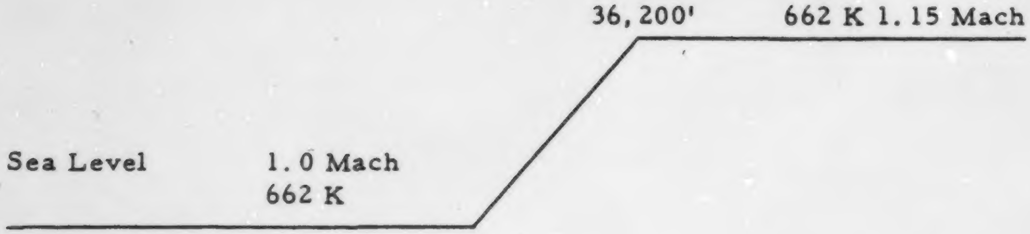
1. b and c

1183

Frame 6

To explain operation of the machmeter we will use the illustration below. We will use only one diaphragm and one aneroid. When the speed of the aircraft increases, the pitot pressure inside the airspeed diaphragm increases causing it to expand. The expansion of the diaphragm moves the mechanical linkage, increasing the Mach number indication. As altitude is increased, the aneroid expands, pushing the floating shaft to a new position. This movement changes the leverage ratio between the sector lever and the rocking shaft lever. This "speeds up" pointer movement. If the aircraft maintained the same airspeed and increased its altitude, the Mach number would increase. (See the illustration below.)


INCREASE MACH NUMBER
SECTOR LEVER
ROCKING SHAFT LEVER
ALTITUDE INCREASE
FLOATING ROCKING SHAFT
AIRSPEED INCREASE
ALTITUDE DIAPHRAGM (ANEROID)
AIRSPEED DIAPHRAGM
PITOT PRESSURE


36,200'
662 K 1.15 Mach
Sea Level
1.0 Mach
662 K

1215

1. Circle the letters that identify true statements.

   a. An increase in altitude up to 36,000' causes a decrease in the speed of sound.

   b. An increase in pitot pressure causes a decrease in Mach number.

   c. As altitude is increased, the aneroids expand.

   d. If the aircraft maintained the same speed and decreased altitude, the Mach number should increase.

   e. An increase in aircraft speed causes pitot pressure to increase.

Answers to Frame 5:

1. c   2. a and b

Answers to Frame 6:

1. a, c, and e.

APPRAISAL

WORKBOOK
3ABR32531-WB-301

Technical Training

Avionics Instrument Systems Specialist

OPERATIONAL CHECK, INSPECTION TROUBLESHOOTING AND BENCH CHECK OF THE PITOT-STATIC SYSTEM

7 March 1977

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3360th Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71 STANDARD COVERSHEET

1186

Instrument/Flight Control Branch
Chanute AFB, Illinois

Section 1. BENCH CHECK VERTICAL VELOCITY INDICATOR

OBJECTIVES

Given a workbook, test equipment and trainer, perform an inspection and operational check of a pitot-static system with a minimum of 100% accurate workbook responses.

Given a workbook, test equipment and trainer, troubleshoot a pitot-static system with a minimum of 75% accurate workbook responses.

Given a workbook, test equipment and trainer, bench check components of a pitot-static system with a minimum of 80% accurate workbook responses.

EQUIPMENT

	Basis of Issue
A-1 Mercurial Barometer	1/student
Vertical Velocity Indicator	1/student
Vacuum Chamber	1/student
Timer	1/student
Screwdriver	1/student

INSTRUCTIONS

The laboratory station instructor will supply you with the required equipment necessary to complete the workbook. The workbook is divided into four sections; at the end of each section the instructor will check your work. Follow each step carefully and complete the workbook as required. Take your time and DO NOT RUSH. If you have difficulty on any of the steps, check with your instructor BEFORE attempting to complete the step.

PROCEDURE

Note: Ask your instructor for the required equipment. Perform the required bench checks on the vertical velocity indicator and record the results in the following tables. If you have difficulty on any of the following steps, check with your instructor.

Caution: Remove all jewelry.

THIS SECTION OF THE WORKBOOK GIVES INFORMATION AND PROCEDURES FOR PREPARING THE A-1 MERCURIAL BAROMETER FOR BENCH CHECKING THE VERTICAL VELOCITY INDICATOR.

Supersedes 3ABR32531-WB-301A, 9 January 1976; 3ABR32531-WB-301B, 9 December 1975; 3ABR32531-WB-301D, 23 January 1976; 3ABR32531-WB-301E, 26 February 1975.

1218

OPR: 3360TTG
DISTRIBUTION: X
3360TTGTC-W - 200; TTVSR - 1

1. Leveling the A-1 mercurial barometer.

a. The barometer has three leveling screws located on the barometer mount platform, two in front and one on the rear of the platform. There are also two bubble levels on the mount platform, one on the left side and one on the rear of the platform.

b. Use figure 1 and locate the leveling screws and the bubble levels on the barometer mount platform.

2. Perform the following steps on the A-1 mercurial barometer:

a. Locate the three leveling screws.

b. Locate the two bubble levels.

c. Level the A-1 mercurial barometer.

d. Is the bubble in the center of the levels? If so, proceed to the next step.

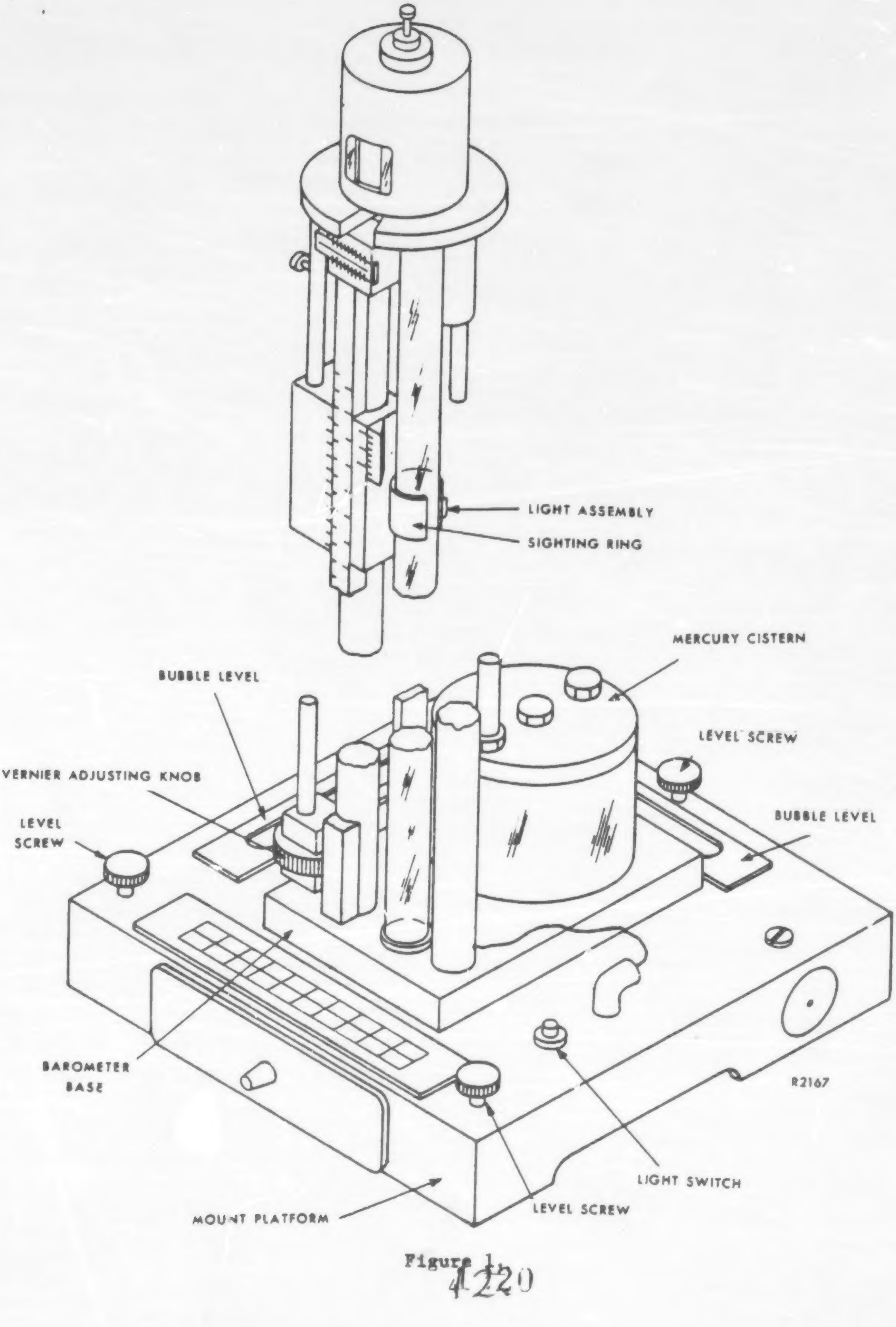

LIGHT ASSEMBLY
SIGHTING RING
MERCURY CISTERN
BUBBLE LEVEL
LEVEL SCREW
VERNIER ADJUSTING KNOB
BUBBLE LEVEL
LEVEL SCREW
BAROMETER BASE
R2167
LIGHT SWITCH
LEVEL SCREW
MOUNT PLATFORM

Figure 1.

3. Altitude scale and altitude index.

a. The altitude scale is read against the altitude index. (Refer to figures 2 and 3.) Altitude index reference mark is located in line and to the left of the bottom of the sighting ring.

b. The altitude scale is graduated in:

(1) 100 foot increments from -1,000' to +10,000'.

(2) 500 foot increments from +10,000' to +50,000'.

(3) 1,000 foot increments from +50,000' to +80,000'.

c. Use figures 2 and 3 to locate the altitude scale and altitude index marker on the A-1 mercury barometer.

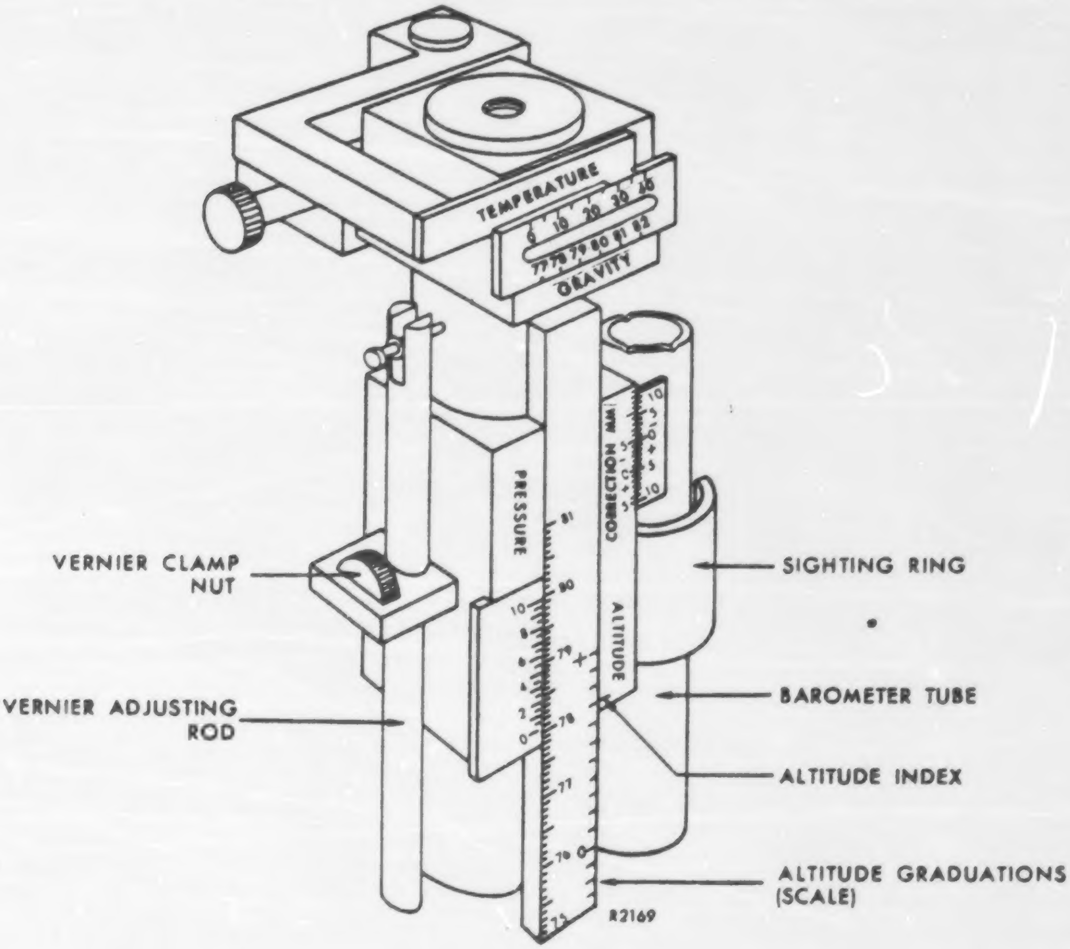

TEMPERATURE
0 10 20 30 40
77 78 79 80 81 82
GRAVITY
PRESSURE
CORRECTION MM
ALTITUDE
VERNIER CLAMP NUT
VERNIER ADJUSTING ROD
SIGHTING RING
BAROMETER TUBE
ALTITUDE INDEX
ALTITUDE GRADUATIONS (SCALE)
R2169

Figure 2.

1190

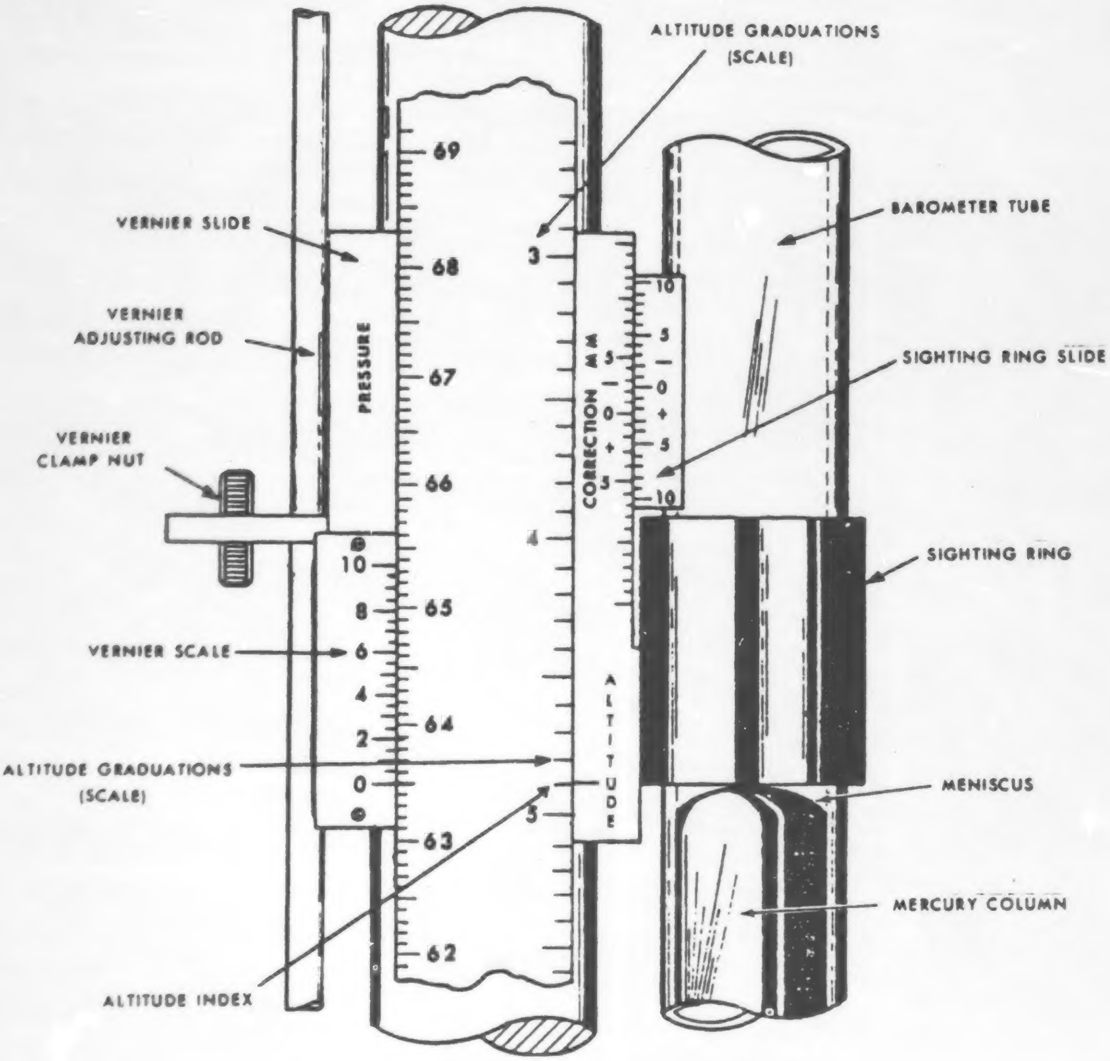

ALTITUDE GRADUATIONS (SCALE)
BAROMETER TUBE
VERNIER SLIDE
VERNIER ADJUSTING ROD
PRESSURE
SIGHTING RING SLIDE
CORRECTION MM
VERNIER CLAMP NUT
SIGHTING RING
VERNIER SCALE
ALTITUDE
ALTITUDE GRADUATIONS (SCALE)
MENISCUS
MERCURY COLUMN
ALTITUDE INDEX
69
68
67
66
65
64
63
62
3
4
5
10
8
6
4
2
0

Figure 3.

Fill in the blank spaces of the following questions.

1. The A-1 mercury barometer altitude range in feet is from

________' to ______________'.

2. Using figure 3, the altitude index is indicating approximately

______________'.

1222

4. Vernier clamp nut and sighting ring. (Figure 2 or 3)

a. The vernier clamp nut, if unclamped, is used to move the sighting ring and the altitude index up and down to select various altitudes when you are performing a bench check on the vertical velocity indicator.

b. The vernier adjusting knob (figure 1) is used for fine adjustment of the altitude index to the altitude graduations.

Perform the following step on the A-1 mercury barometer.

5. Use the vernier clamp nut and the vernier (fine) adjusting knob to select the following altitude ranges:

a. 2,000 ft.

b. 4,000 ft.

c. 18,000 ft.

d. 24,000 ft.

6. Light assembly and light switch.

a. The light assembly (figure 1) is used as an aid to align the sighting ring to the top of the mercury meniscus.

b. The light switch is located on the top of the barometer mount platform (reference figure 1).

c. For proper alignment of the sighting ring to the top of the mercury meniscus, study figure 4 carefully.

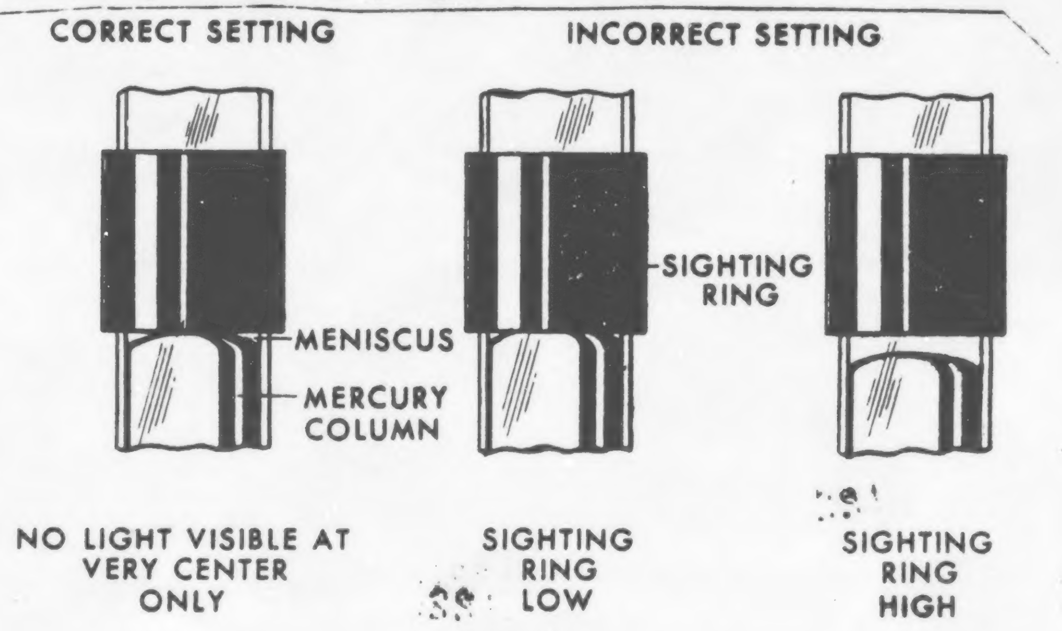

CORRECT SETTING
INCORRECT SETTING
SIGHTING RING
MENISCUS
MERCURY COLUMN
NO LIGHT VISIBLE AT VERY CENTER ONLY
SIGHTING RING LOW
SIGHTING RING HIGH

Figure 4.

YOU ARE NOW READY TO BENCH CHECK THE VERTICAL VELOCITY INDICATOR. PROCEED BY ACCOMPLISHING THE FOLLOWING STEPS.

1. Zero Setting Check, Table 1.

a. Purpose: Used to set the pointer to zero to correct for error due to stresses or wear.

b. Turn the zero setting screw on the front of the indicator with the screwdriver. Note the maximum points reached by the pointer.

c. Record the maximum readings of the pointer in table 1 as feet-per-minute and as satisfactory (S) or unsatisfactory (U), according to the tolerances given.

d. Set the pointer back to zero, tapping the indicator to make sure all friction is removed.

Note: To provide vibration (or tapping) for the indicators, roll the screwdriver handle on the instrument case or the vacuum chamber.

Check	Tolerance	Results	S/U
Zero Setting	Minimum of 400 Feet Per Minute (fpm)	Up:	
		Down:	

Table 1. Zero Setting Check.

2. Position Error Check, Table 2.

a. Purpose: To determine if there is an excessive amount of play in the mechanical linkage.

b. While looking at the face of the indicator, rotate the vertical velocity indicator clockwise 360 degrees, vibrate and read it at each 90 degree position.

c. Record the indicator's readings at each of these four positions in table 2.

d. Record each result as feet-per-minute and as "S" or "U," according to the tolerances given.

Check	Tolerance	Results							
Position Error	± 50 fpm	0°	S/U	90°	S/U	180°	S/U	270°	S/U

Table 2. Position Error Check.

3. Lag Test, Table 3.

a. Purpose: Checks the condition and calibration of the diffuser valve.

b. Open the "vent" valve and close the "vac/press" valve on the vacuum pressure panel.

c. Place the zeroed vertical velocity indicator in the vacuum chamber so the dial is easy to view through the window in the chamber's door.

d. Close and lock the chamber door.

Note: To get a better seal, tighten the two wing nuts closest to the hinge first.

e. Close the "vent" valve of the vacuum pressure panel.

Note: Before proceeding, apply power to the timer and familiarize yourself with its operation. Carefully read steps f, g, h, and i.

f. Open the "air pressure" source valve on the back of the bench, about three turns.

Call Instructor.

Caution: When checking the pressure portion of this test, do not allow the mercury to rise past the top of the glass column.

g. Open the vac/press valve on the control panel slowly and steadily until the vertical velocity indicator indicates 4,000 fpm dive.

h. Quickly shut off the "vac/press" valve and open the "vent" valve allowing the pressure to escape rapidly.

(1) The pointer will pass zero and indicate between 2,500 and 5,000 feet-per-minute climb.

(2) As the pointer begins to move toward zero, vibrate the vacuum chamber to remove friction from the indicator and time the pointer from 2,000 to 200 feet-per-minute using the timer.

i. Record the time in seconds in table 3 in the blank after the word "pressure."

Check	Tolerance	Results	S/U
Lag Test	7-12 Seconds	Pressure: __________ seconds	
		Vacuum: __________ seconds	

Table 3. Lag Test.

j. Indicate with an "S" or "U" whether the check is satisfactory or unsatisfactory according to the tolerance given.

k. Shut off the "air pressure" valve on the back of the bench and turn on the "vacuum" valve on the back of the bench.

l. Repeat steps 3g through 3j using vacuum and recording the results in seconds in table 3 in the blank after the word "vacuum."

m. Close vent valve on vac/pres chamber.

4. Scale Error Check.

Note: The A-1 Mercurial barometer and timer are used as master indicators when checking the vertical velocity indicator to determine if scale error is present. Scale error is the difference between the indicated rate of the indicator under test and the actual (true) rate determined from the master indicator. If the indicated rate is greater than the actual rate, it is a plus error and if less than the actual rate, it is a minus error. Later in the text you will use a formula to compute the error. To obtain actual (true) rate of change, check the time required for the mercury in the barometer to go from one altitude setting to another.

a. Purpose: To check the scale accuracy of the indicator.

Note: Read step 4b through step 4k before you start performing your checks; also vibrate the vacuum chamber to remove friction from the indicator inside the chamber while performing the scale error check.

b. Lower the barometer's sighting ring to 2,000 feet on the barometer's altitude scale.

c. Close the "vent" valve on the vacuum chamber.

d. Using vacuum, slowly open the "vac/press" valve on the vacuum pressure panel and tap the chamber until the vertical velocity indicator indicates 2,000 feet-per-minute.

(1) DO NOT shut the "vac/press" valve off when the indicator indicates 2,000 feet per minute. Remember the indicator is showing the rate at which the altitude is changing. If you shut the valve off, the pointer will return to zero because altitude (pressure) is no longer changing.

(2) It will take a little practice to learn how to control the vacuum at a steady rate.

e. The barometer's mercury column should be dropping at the rate of 2,000 feet per minute.

f. When the mercury reaches the bottom of the sighting ring, start timing it with the timer.

g. Always check the vertical velocity indicator to make sure it is still indicating 2,000 feet-per-minute.

h. Slide the sighting ring down to 4,000 feet on the barometer's altitude scale.

Altitude Interval In Feet	Indicated (Indicator) Rate In FPM	Time In Seconds	Actual Rate (True) In FPM	Error In FPM	S / U	Tolerance In FPM
2000-4000	2000 Up					300
4000-2000	2000 Dn					300
2000-4000	3000 Up					300
4000-2000	3000 Dn					300
2000-4000	4000 Up					400
4000-2000	4000 Dn					400
2000-4000	5000 Up					500
4000-2000	5000 Dn					500
15000-17000	3000 Up					350
17000-15000	3000 Dn					350
28000-30000	2000 Up					300
30000-28000	2000 Dn					300
28000-30000	4000 Up					400
30000-28000	4000 Dn					400

Table 4.—Scale Error Check.

i. When the mercury column again reaches the bottom of the sighting ring, stop the timer. Record the time it took the mercury column to move from 2,000 feet to 4,000 feet in the column labeled "Time in Seconds" in table 4.

> Note: When the mercury column reaches 4,000 feet altitude or bottom of the sighting ring and you have stopped your timer, do not close the vacuum source valve. Let the mercury continue downscale to approximately 4,800 feet before you close the source valve and stop the mercury column. Now you are ready to proceed to step j.

j. After the indicator under test stabilizes to "0" fpm, use the "vent valve," of the vacuum pressure panel to slowly release the vacuum at the rate of 2,000 feet-per-minute dive on the vertical velocity indicator.

k. When the mercury column reaches the bottom of the sighting ring, start the timer.

Note: Reread steps 4b through 4k thoroughly until procedure is completely understood.

Caution: Never exceed 5,000 fpm climb or dive during this bench check.

(1) Move the sighting ring back to 2,000' on the barometer's altitude scale and stop the timer when the mercury column reaches this 2,000' mark at the bottom of the sighting ring.

(2) Record the time it took the mercury column to move from 4,000' to 2,000' in the column labeled "Time in Second."

Note: The remaining checks in table 4 are performed in the same manner except that the indicated rate changes, so it will take less time for the mercury column to move from one altitude test point to the other.

5. Upon completion of the bench check, perform the following:

Caution: Do not exceed a dive indication on the indicator of more than 5,000 fpm when lowering the mercury column back to field elevation.

a. Lower the mercury column down from 28,000 feet to pressure altitude.

b. Open the vacuum chamber door when the mercury column has reached ambient pressure, remove the indicator and close the vacuum chamber door. Shut off vacuum source valve on the back of the bench, and open vent valve.

c. Place cover on A-1 mercury barometer and put your equipment (screwdriver, timer and vertical velocity indicator) away.

d. Return to the reading room with your workbook and figure out the actual (true) rate of climb by using the following formula:

Note: To determine the interval to be used in the formula, refer to Table 4, and use the extreme left hand column.

Example: Altitude Interval In Feet; 2,000-4,000. The difference between the two numbers is 2,000 foot interval.

$$\text{Actual Rate (True)} = \frac{\text{Altitude Interval (in feet)}}{\text{Time (in seconds)}} \text{ X } \frac{60}{1}$$

Example: The indicated rate is 2,000 feet per minute. To figure scale error, let's work this problem together.

Altitude Interval = 2000 feet

Time in Seconds = 55 seconds

$$\text{Actual Rate} = \frac{2000 \text{ feet}}{55 \text{ seconds}} \times \frac{60}{1} = \frac{120000}{55} = 2182 \text{ feet per min.}$$

The scale error is minus 182 feet per minute, because the indicated rate was 2000 feet per minute which is 182 feet-per-minute less than the actual rate of 2,182 feet-per-minute.

e. The error of the instrument is the difference between the actual rate (true) and the indicated rate.

(1) Remember you are trying to determine how much scale error the indicator has.

(2) If the indicated rate is more than the actual (true) rate, this is a plus (+) error. If the indicated rate is less than the true rate, this is a minus (-) error.

f. Be sure to indicate with the error whether the result is satisfactory (S) or unsatisfactory (U) according to the tolerances given.

g. After completing this workbook, have the lab instructor check your work.

1198

Section 2. BENCH CHECK OF THE ALTIMETER

THIS SECTION OF THE WORKBOOK COVERS INFORMATION AND PROCEDURES FOR PREPARING THE A-1 MERCURIAL BAROMETER FOR BENCH CHECKING THE ALTIMETER.

EQUIPMENT

	Basis of Issue
A-1 Mercurial Barometer	1/student
Altimeter	1/student
Vertical Velocity Indicator	1/student
Vacuum Chamber	1/student
Screwdriver	1/student
Training Film, AVA 550, Altimeter Setting Adjustment	1/student

PROCEDURE

Ask your instructor for the required equipment. Perform the bench check on the altimeter and record the results as appropriate. If you have difficulty on any of the following steps, check with your instructor.

Caution: Remove all jewelry.

1. The first adjustment made on the A-1 mercurial barometer before it can be properly used is the leveling adjustment. Remove the cover from the A-1 barometer, look at the base, and see if you can find two levels and three adjusting screws. (Refer to figure 1.) To level the A-1 barometer you must adjust the three screws until the bubbles in the two levels are centered. Check the barometer in front of you and level it if it is not level.

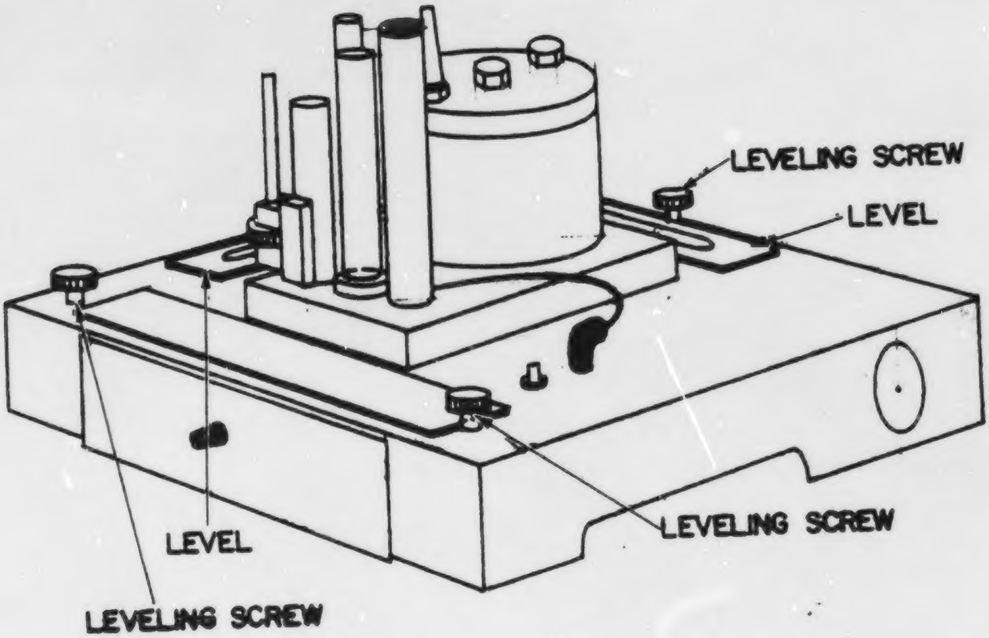

LEVELING SCREW
LEVEL
LEVELING SCREW
LEVEL
LEVELING SCREW

Figure 1.

2. The second adjustment on the A-1 mercurial barometer is the temperature adjustment. To make this adjustment, read the centrigrade thermometer that is located on the right side of the barometer tube about midway down. The thermometer reads __________°C.

3. Now that you know the temperature, set it in. Look at the top of the barometer. There you will find a scale, the upper portion being the temperature scale. (Refer to figure 2.) The index mark above the temperature scale can be adjusted to the correct temperature by rotating the knob on the upper left of the barometer. Turn it now and adjust the **temperature scale to the temperature recorded in step 2 above.**

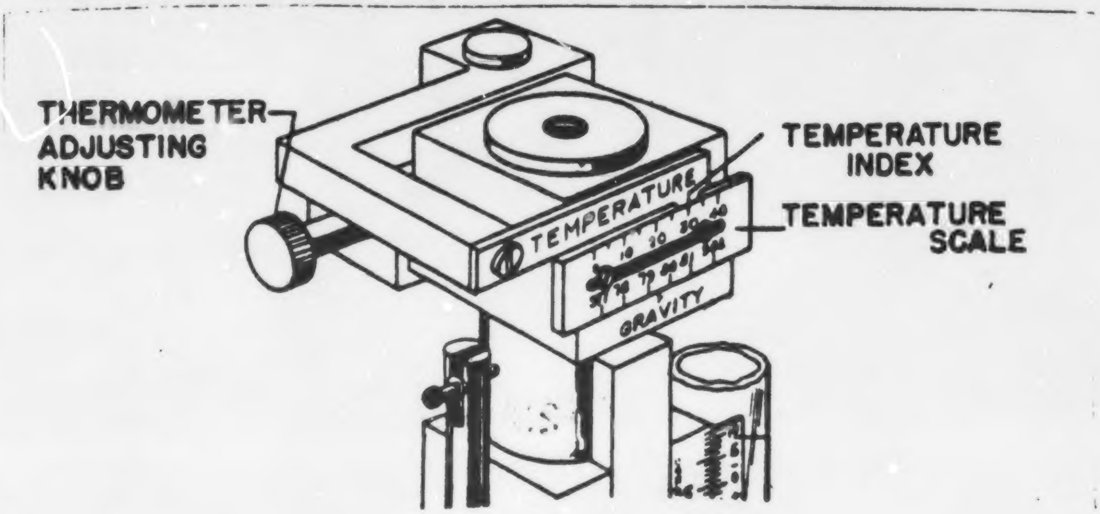

THERMOMETER ADJUSTING KNOB
TEMPERATURE INDEX
TEMPERATURE SCALE
TEMPERATURE
10 20 30 40
GRAVITY

Figure 2.

1200

4. The barometer is now correctly adjusted and ready to use. Tap the table to aid in adjusting the meniscus shape of the mercury in the tube. Unlock the vernier clamp nut and adjust the vernier slide assembly until the lower edge of the sighting ring is in line with the top of the mercury column. Use figure 3 as an aid for setting the sighting ring correctly.

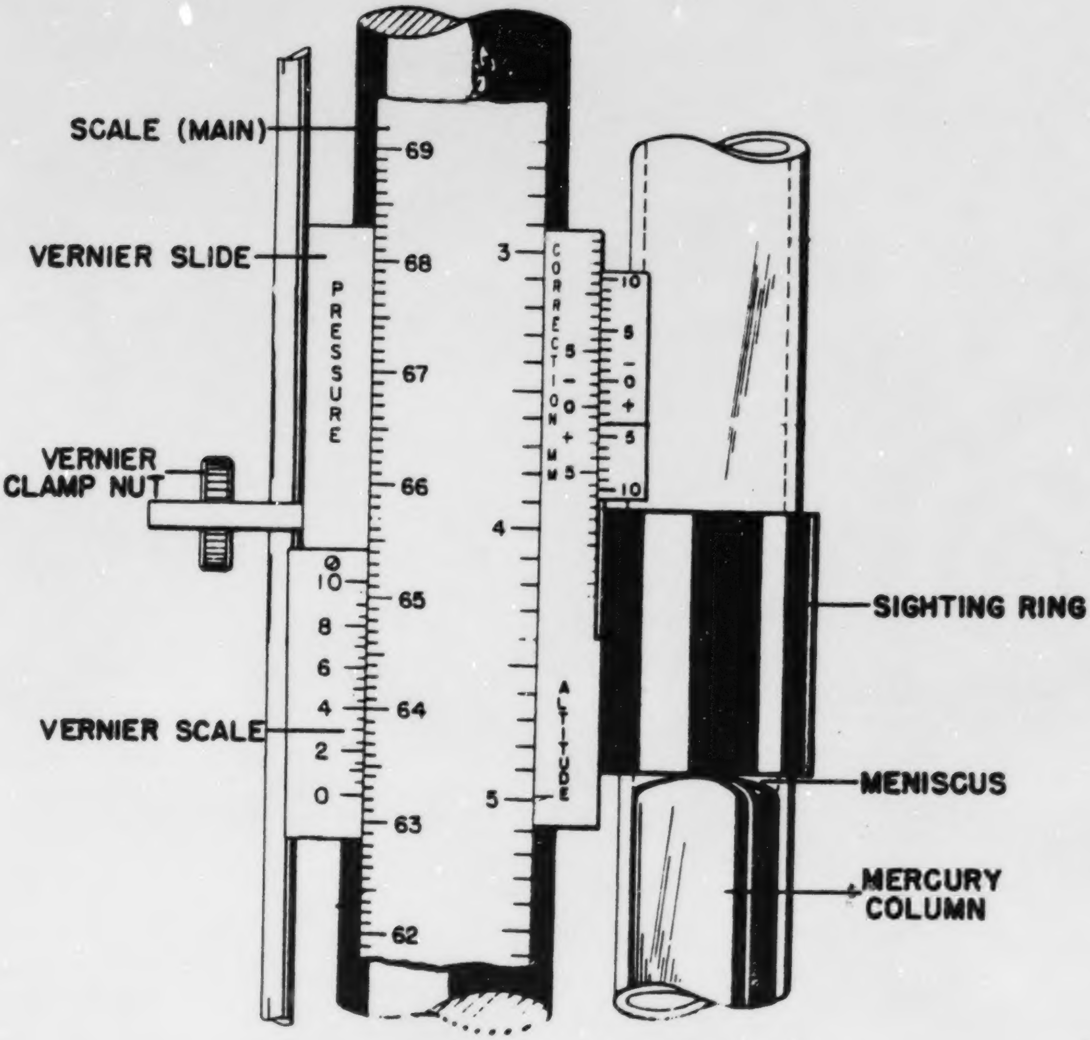

SCALE (MAIN)
VERNIER SLIDE
VERNIER CLAMP NUT
VERNIER SCALE
SIGHTING RING
MENISCUS
MERCURY COLUMN
PRESSURE
CORRECTION MM
ALTITUDE
69
68
67
66
65
64
63
62
3
4
5
10
8
6
4
2
0
10
5
0
5
10
5
0
5

Figure 3.

5. The left side of the scale on the A-1 mercurial barometer is calibrated in millimeters of mercury (mmHg). Notice on the preceding illustration, the millimeter scale is numbered every tenth line with the final zero removed, thus 630 mmHg would be shown as 63 on the scale. To take a reading from the barometer we use 0 on the vernier scale as an index mark and read the millimeter scale against it. Reading the indication on the illustration, the index mark is two increments above 630, and since each increment equals 1 mmHg, you can see the indication is 632 mmHg. Locate the first number on the vernier scale that is aligned to an index mark on the main scale, which in this case would be 4. The indication shown in the illustration is 632.4 mmHg. Now read the A-1 barometer in front of you and record the indication in the space provided below. Note: If you don't understand how to read the millimeter scale, check with the instructor.

Your A-1 barometer indication is ________________ mmHg.

6. In paragraph 5 you recorded the reading of the A-1 mercurial barometer in mmHg. To use this reading with the altimeter, you must convert the reading to pressure altitude in feet and local pressure in inches of mercury. A chart on the back of the bench is used for these conversions. Notice that the left side of the chart is labeled "Pressure Altitude Chart" and the right side is "Millimeters - Inches Chart." For a practice exercise, let's assume that the barometer read 690.0 mmHg. To convert this reading to pressure altitude, use the side of the chart labeled "Pressure Altitude Chart." Start at the lower right side of the chart and move a pencil on your finger along the bottom of the scale until you locate 690 mmHg. Now move directly up to the top part of the scale from 690 mmHg and you will read a pressure altitude of 2650 feet. To convert 690 mmHg to inches of mercury, you must refer to the right side of the chart marked "Millimeters - Inches Chart," and again locate 690 mmHg on the bottom of the scale. Again move up to the top of the scale from 690 mmHg and you will read 27.17 inches of Hg.

For practice, use the chart to convert the following:

1. 736.6 mmHg = ________ inches Hg.

2. 741.4 mmHg = ________ inches Hg.

3. 741 mmHg = _______ feet pressure altitude.

4. 724.6 mmHg = ________ feet pressure altitude.

Note: Call the instructor, he will verify above readings.

ALTIMETER SETTING ADJUSTMENT

1. Perform a visual inspection of the altimeter and complete checks a. through c. listed below. Enter an S (Satisfactory) or U (Unsatisfactory) in the space provided.

a. Appearance of case, including chips and cracks ______.

b. Burred or loose screws ______.

c. Scratched, discolored, or loose glass ______.

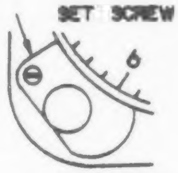
Note: See film AVA 550, Altimeter Setting Adjustment.

2. Perform the zero setting check. (Mechanical linkage check).

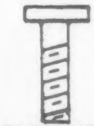
a. Set the pointers of the altimeter at zero feet.

b. Vibrate the altimeter to remove any friction and reset the pointers to zero if necessary.

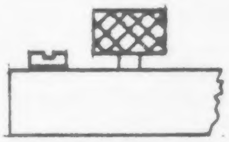
c. Loosen the baro setscrew by turning it counterclockwise until the shoulder of the screw rises above the surface surrounding it. Be careful so that you don't turn the screw so far that it falls out.



TOP VIEW

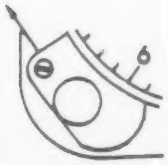


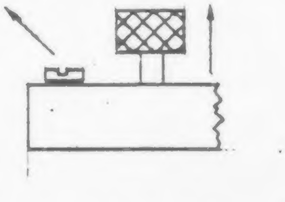
SHOULDER OF SCREW



SIDE VIEW

d. Rest the back of the altimeter on the bench holding the altimeter in the upright position, move the screw up and to the left to unlock the baro set knob.





e. Pull out the baro set knob and set the barometric scale to 29.92" Hg. The altimeter pointers should still indicate zero feet. If the pointers read other than zero feet, go back to step a.

f. Push the baro set knob in and lock the setscrew by sliding the screw back to its original position and turning it clockwise, lock the baro set knob in place. Turn the baro set knob to see if both pointers and barometric scale move as they should.

g. Turn the baro set knob until the barometer scale is indicating 28.50" Hg. Tap the indicator and enter the indication in Table I. Compare the indications of the pointers to the tolerance listed and enter an (S) or (U) in the space provided. Complete the remaining checks in Table I.

Barometric Scale Setting	Correct Pointer Indication	Tolerance	Instrument Reading in Ft.	S or U
28.50" Hg	-1,340'	±25'		
29.92" Hg	0'	±25'		
30.90" Hg	+893'	±25'		

Table I. Mechanical Linkage Check.

3. Perform an altimeter setting adjustment. This adjustment is made to insure the pointers will be synchronized with the barometric disc.

a. Record the mmHg that you read on the barometer in the space provided in Table II. (Paragraph 5 of section A on page 4).

b. To prepare the altimeter for an altimeter setting, the following steps are necessary:

(1) Local pressure must be changed to sea level pressure as the starting point. This is accomplished by adding .1" Hg to the barometric scale indication for every one hundred feet of field elevation. (This must be done any time a new altimeter is installed in an aircraft and/or periodically checked.)

(2) Chanute Air Force Base has a surveyed field elevation of 744' above sea level. When field elevation is between the hundred foot marks it should be increased to the next higher elevation which in this case would be 800 feet. This means we must add .8" Hg to the barometric indication obtained from the barometer after conversion, explained in next paragraph.

(3) You should have the barometric reading obtained from paragraph 5, page 4, recorded in the first block of Table II. The barometric reading must be converted to Pressure Altitude in the next block. Pressure Altitude must be converted to " Hg which is Local Pressure in " Hg. Add .8" Hg to Local Pressure to obtain the Altimeter Setting.

Barometer Reading	______________	mmHg
Pressure Altitude	________ ______	Feet
Local Pressure	__ __ . __ __	"Hg
Altimeter Setting	__ __ . __ __	"Hg

Table II.

c. Set in field elevation on your altimeter (744 feet for Chanute).

d. Unlock the baro locking screw as you did in item 2c.

e. Pull out the baro set knob and set in the altimeter setting recorded in Table II. Only the barometric scale should move; if the pointers move, go back to step d.

f. Push in the baro set knob and turn the locking screw clockwise, until tight, to lock the baro set knob in position.

g. The altimeter is now set. For bench check purposes turn the baro set knob until the baro scale indicates 29.92 inches of mercury. The pointers must indicate the pressure altitude recorded in Table II. If the pointers don't, set in the pressure altitude recorded in Table II into the altimeter. The altimeter will now indicate the same reading as the right hand scale of the A-1 barometer.

4. Perform the scale friction error bench check.

a. Zero the vertical velocity indicator and place it and the altimeter into the vacuum chamber.

b. Close the vacuum chamber door and tighten the wing nuts finger tight.

c. Open the vacuum valve located on the rear of the work bench.

d. Remember that scale error is the difference between the test point and the indicator's after tap indication. Friction error is the difference between the before and after tap indications. In recording these errors, remember that scale error must always have a plus (+) or minus (-) sign with it and an (S) or (U) according to the tolerance at the test point. Friction error never has a sign but must have an (S) or (U) according to the tolerance.

Note: Read paragraphs d through h before beginning this test.

e. Close the vent valve and begin Table III. Move the sighting ring of the barometer to each test point provided, then apply vacuum until you reach that test point. The barometer is the master instrument for this test. The first test point is 1,000 feet. Caution: Never exceed 3000 FPM on the vertical velocity indicator when changing from one altitude check point to the next altitude check point.

Note: Close VAC/Press source valve at each test point.

f. Record the indication of the altimeter in the space provided in Table III.

g. Vibrate the altimeter and record the indication in the after tap column in Table III.

h. Enter the scale error in the space provided in Table III. Match the scale error to its tolerance and place an (S) or (U) in the space provided.

i. Enter the friction error in the space provided in Table III and match the friction error to its tolerance and place an S or U in the space provided.

j. Complete the remaining checks in Table III.

INSTRUMENT INDICATIONS			TOLERANCE IN FEET		RESULT OF CHECK			
Test Point	Before Tap	After Tap	Scale Error	Friction Error	Scale Error	S/U	Friction Error	S/U
1,000'			± 35	70				
2,000'			40	70				
3,000'			45	70				
4,000'			50	70				
5,000'			55	70				
10,000'			80	80				
15,000'			105	90				
20,000'			130	100				
25,000'			155	120				
50,000'			280	250				

. Table III.

Note: Upon reaching 50,000', close the vacuum control valves on the back of the work bench and on the test panel.

5. Hysteresis and after effects. (Check for metal fatigue and ability of the aneroids to contract to their original shape.)

a. Maintain the 50,000' indication for no longer than 5 minutes.

b. To prepare Table IV for these tests: Enter the "Instrument Indications After Tap Reading" from Table III at 25,000 feet into the space provided in Table IV.

c. Vent off the vacuum until the barometer indicates 25,000 feet.

Note: Do not exceed 3,000 feet per minute dive.

d. Wait 5 minutes, vibrate the altimeter, and record the indication in the "Reading After Time Period" column of Table IV.

e. Enter the difference between the two indications, and an (S) or (U) as applicable, in the spaces provided.

f. Complete the 20,000 test point by following the same steps as used on the 25,000 feet test point.

Test Point	**Waiting** Period	Tolerance	**Instrument Indications** After Tap Reading	**Reading After** Time Period	Results	**Satisfactory** Or Unsatisfactory
50,000'	Not Longer Than 5 Minutes					
25,000'	5 Minutes	± 100'				
20,000'	3 Minutes	± 100'				
Pressure Altitude	2 Minutes	± 50'				

Table IV.

g. Vent off the remaining vacuum until the mercury in the barometer stops moving upscale. The point at which the mercury stops will be the "Pressure Altitude." Go back to Table II and record the pressure altitude in the "Instrument Indications After Tap Reading" column.

h. Open the vacuum chamber door and complete the after effects test at pressure altitude in Table IV by entering the indication of the altimeter into the space provided in Table IV and entering an "S" or "U."

i. Remove the altimeter and vertical velocity indicator from the vacuum chamber and set them on the work bench in the normal position.

j. Close the chamber door and tighten the wing nuts finger tight.

Frame 41

6. The Position Error Check.

a. Vibrate the indicator and record the indication in Table V.

b. Turn the altimeter 90° right and record the after tap indication in the space provided in Table V.

Note: If the reading is greater than the normal position, it is a plus (+) error, if it is less, it is a minus (-) error.

c. Enter an (S) or (U) for the tolerance in the space provided in Table V. Note: Indication should not exceed ±20' from normal indication.

d. Complete the remainder of Table V.

Positions	Readings In Feet	Tolerances	Results of Check In Feet	Satisfactory Or Unsatisfactory
Normal				
90° Right		± 20'		
180°		± 20'		
270°		± 20'		

Table V.

7. The bench check of the altimeter is now complete.

a. Cover the A-1 mercurial barometer.

b. Check all pressure and vacuum valves and make sure they are closed.

c. Return the altimeter, vertical velocity indicator and screwdriver to the Instructor.

Section 3. BENCH CHECK OF THE MAXIMUM ALLOWABLE AIRSPEED INDICATOR

EQUIPMENT

	Basis of Issue
Maximum Allowable Airspeed Indicator	1/student
Mercury Manometer	1/student
Water Manometer	1/student
Vacuum Chamber	1/student
Screwdriver	1/student

PROCEDURE

USING THE FOLLOWING PROCEDURE, PERFORM A BENCH CHECK ON THE MAXIMUM ALLOWABLE AIRSPEED INDICATOR.

Caution: Remove all jewelry.

INDICATED AIRSPEED SECTION

1. Preliminary set up of the test equipment.

a. Compare your lab station to figure 1. Are the hoses and screw-on dust caps in the positions shown in figure 1? IF THEY ARE NOT, CALL YOUR INSTRUCTOR IMMEDIATELY!

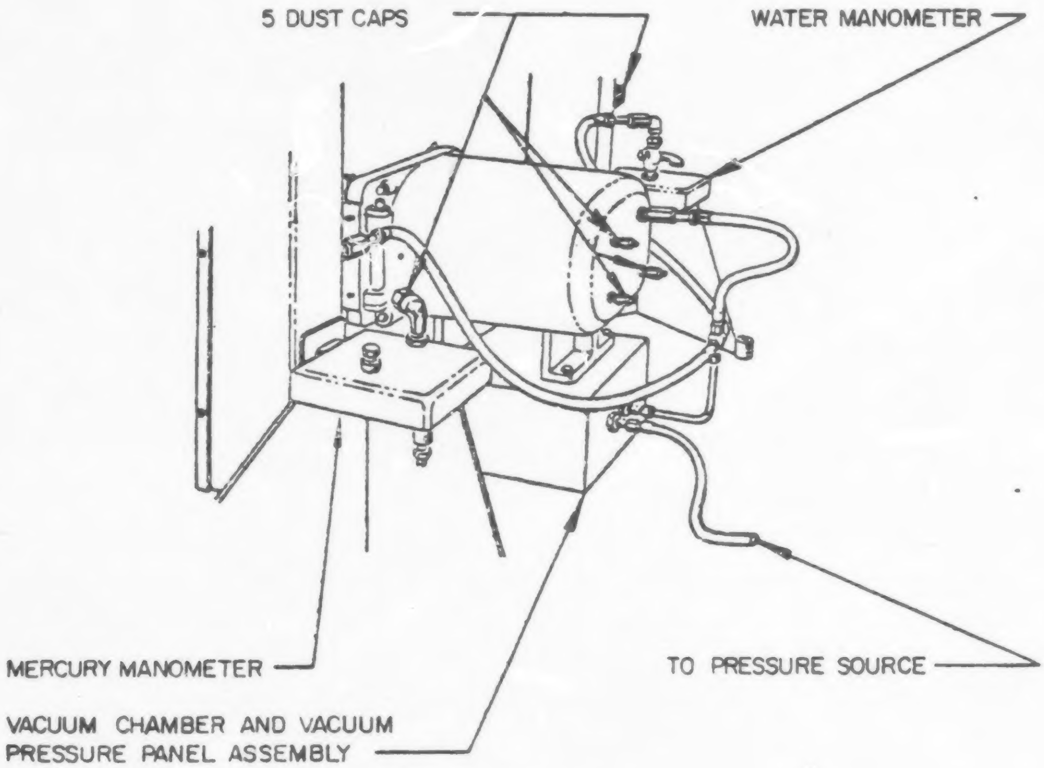

5 DUST CAPS
WATER MANOMETER
MERCURY MANOMETER
TO PRESSURE SOURCE
VACUUM CHAMBER AND VACUUM PRESSURE PANEL ASSEMBLY

Figure 1.

b. Look at the water manometer located to the left of the vacuum chamber. Rotate the scale select knob (large knob, figure 2) until the scale labeled "using water read knots" is in view. The label will be found along the right hand edge of the scale, see figure 2.

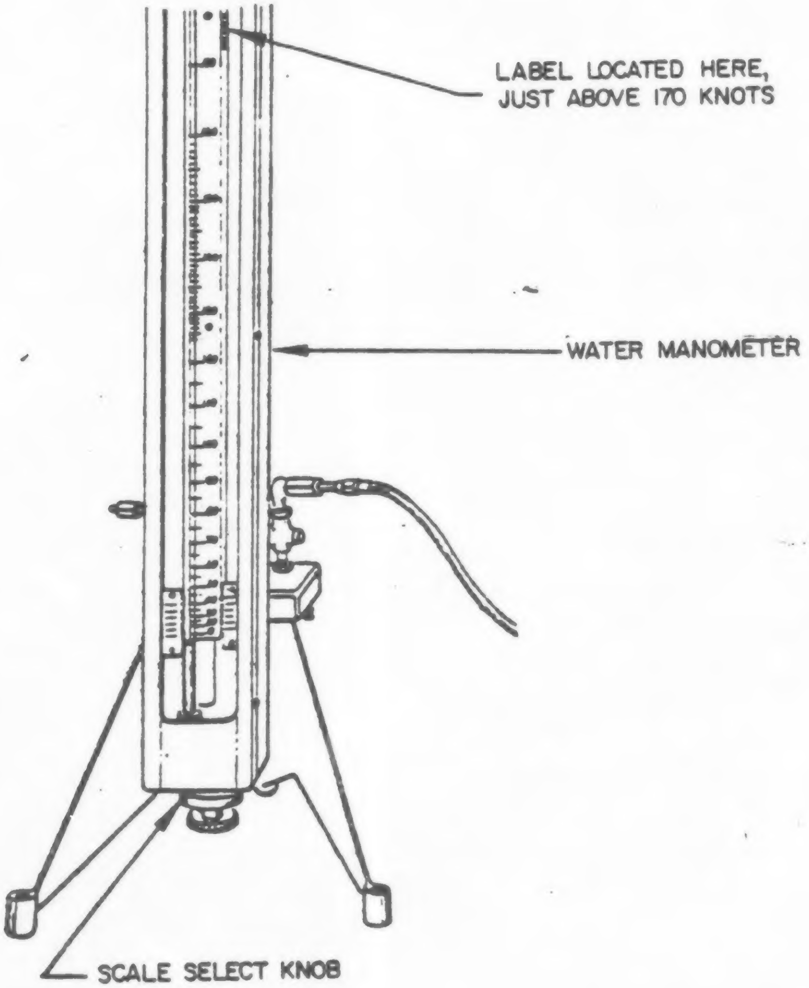

LABEL LOCATED HERE, JUST ABOVE 170 KNOTS
WATER MANOMETER
SCALE SELECT KNOB

Figure 2.

c. Look at the mercury manometer located to the right of the vacuum chamber. Rotate the scale select knob until the scale labeled "using mercury read knots" is in view. The label will be found along the right hand edge of the scale.

d. Locate dust caps A and B in figure 3. Remove dust caps A and B and place them on the bench next to the vacuum chamber.

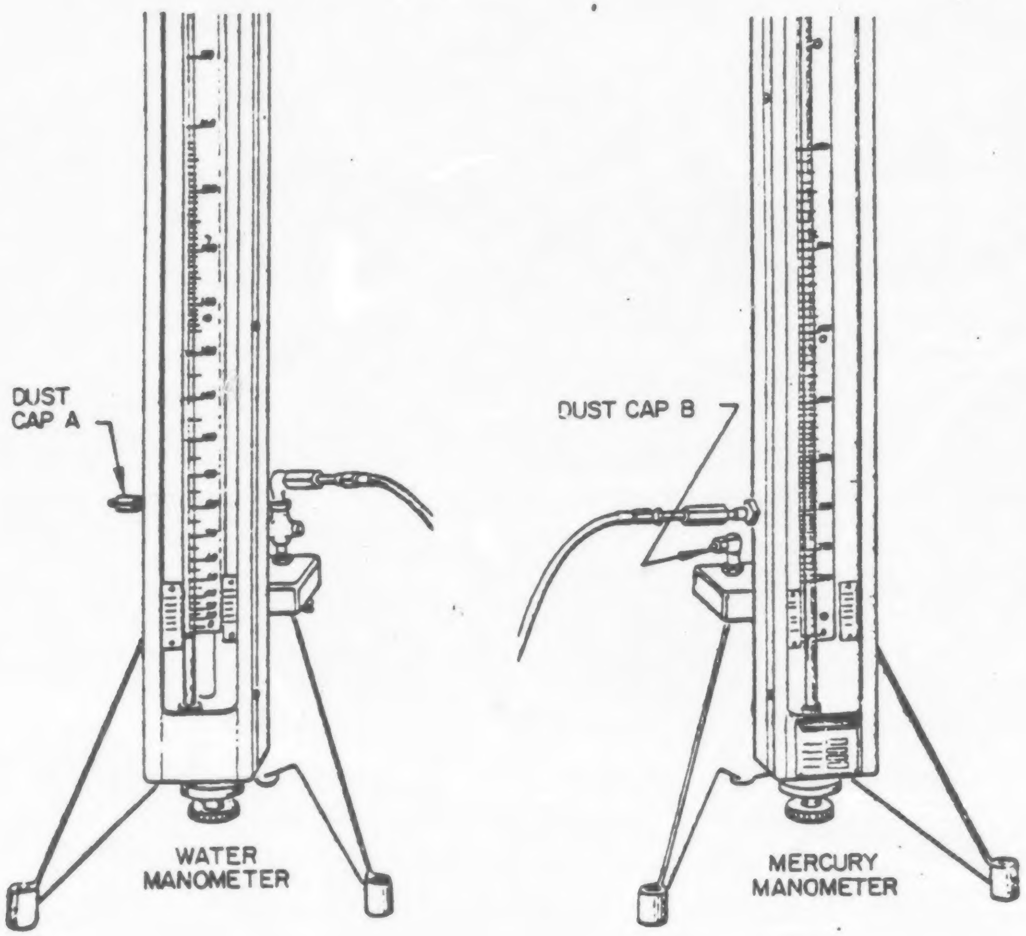

DUST CAP A
DUST CAP B
WATER MANOMETER
MERCURY MANOMETER

Figure 3.

c. Open the vacuum chamber door approximately one inch. Open the "vent" valve at least four turns counterclockwise. Close the "vac/press" source valve by rotating it to a fully clockwise position, see figure 4.

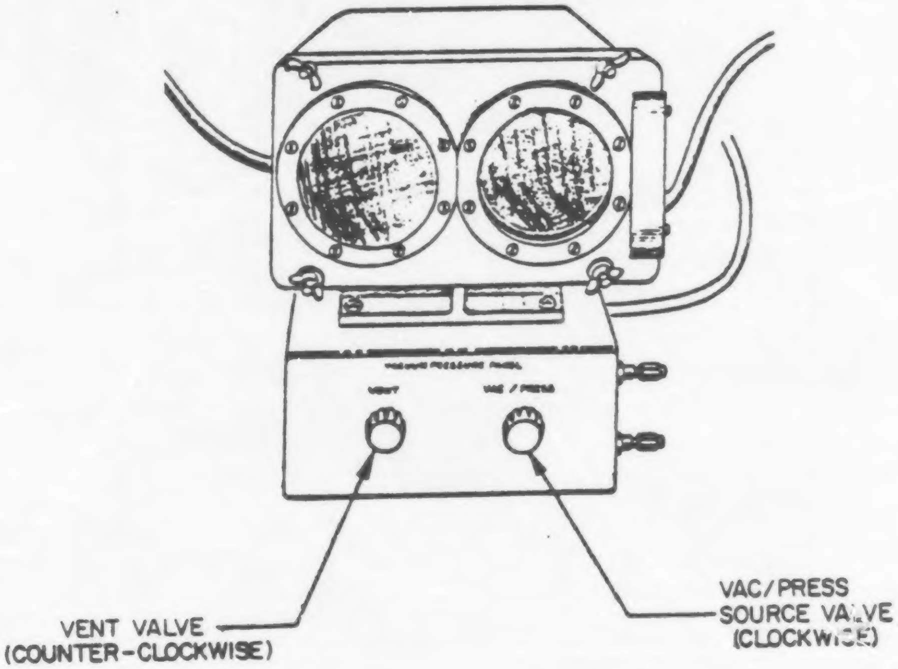

VENT
VAC / PRESS
VENT VALVE
(COUNTER-CLOCKWISE)
VAC/PRESS
SOURCE VALVE
(CLOCKWISE)

Figure 4.

f. Open the pressure valve on the water manometer by turning the arm of the valve so that it is straight up and down, see figure 5.

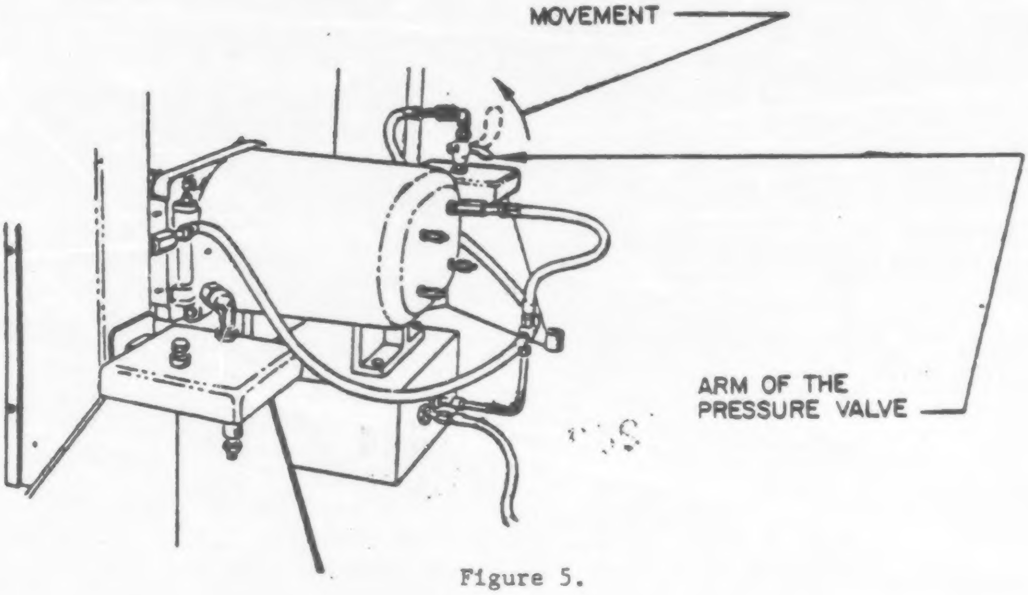

MOVEMENT
ARM OF THE
PRESSURE VALVE

Figure 5.

g. The vacuum and the pressure source valves located at the back of the workbench must be closed finger tight in a clockwise direction, see figure 6.

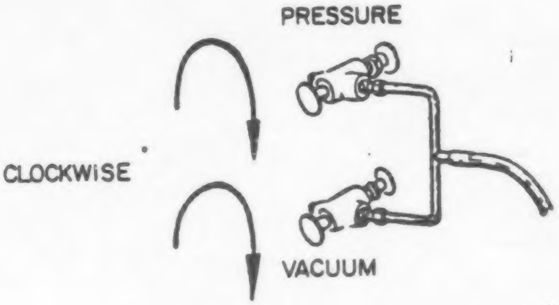


Figure 6.

h. At this point, the system is completely free of external or trapped pressures that would have affected the zeroing of the manometers.

i. Zero the water and mercury manometers by rotating the zero adjustment screw until the zero line on scale is correctly aligned with the water meniscus. Refer to figure 7 - page 29.

> Note: The water manometer is zeroed when the low point of the water meniscus is aligned with the zero line on the manometer scale.
>
> The mercury manometer is zeroed when the high point of the mercury meniscus is aligned with the zero line on the manometer scale.

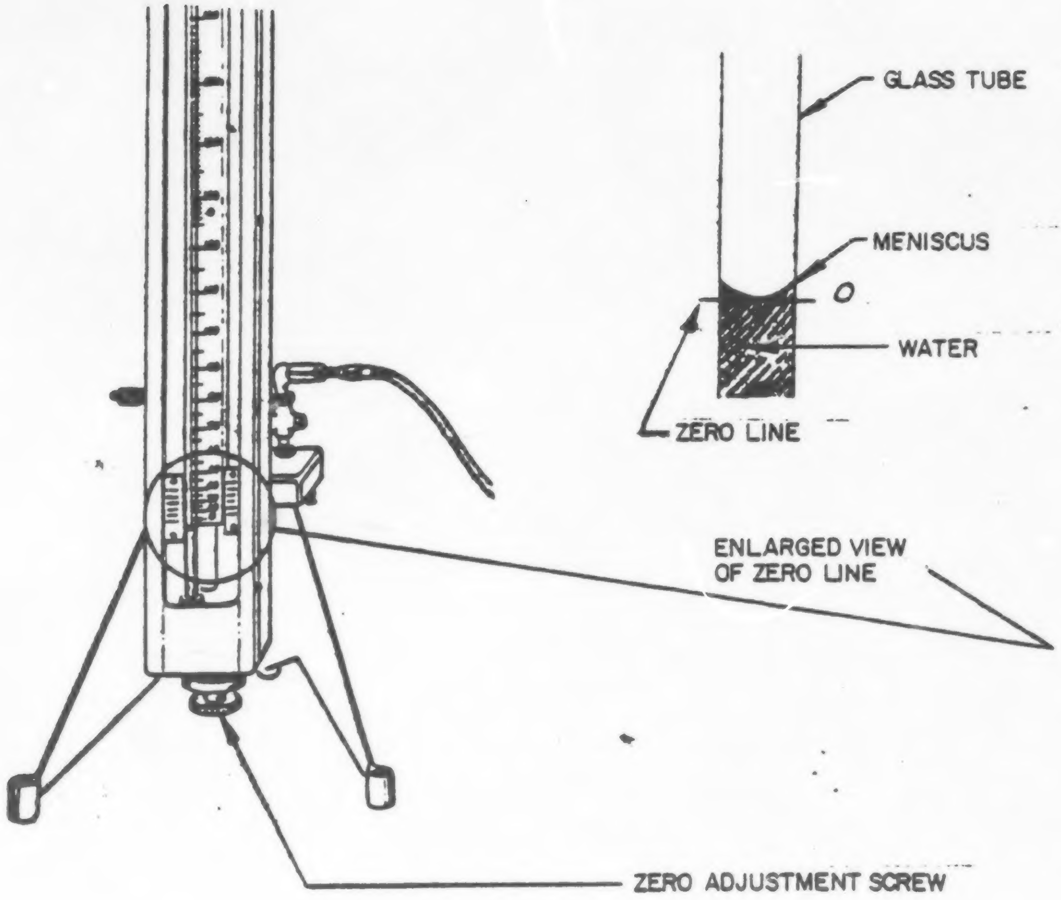

GLASS TUBE
MENISCUS
0
WATER
ZERO LINE
ENLARGED VIEW OF ZERO LINE
ZERO ADJUSTMENT SCREW

Figure 7.

j. Remove hose number 1 from the back of the vacuum chamber by unscrewing the hose adapter from the fitting on the back of the vacuum chamber. The hose adapter must be rotated counterclockwise to remove it, see figure 8a.

(1) Remove the dust cap from the back of the indicator.

(2) Secure hose number 1 to the fitting on the back of the indicator. You must make sure that there is a rubber "O" ring gasket in place and in good condition before the connection is made, see figure 8b.

(3) Place the indicator on top of the vacuum chamber.

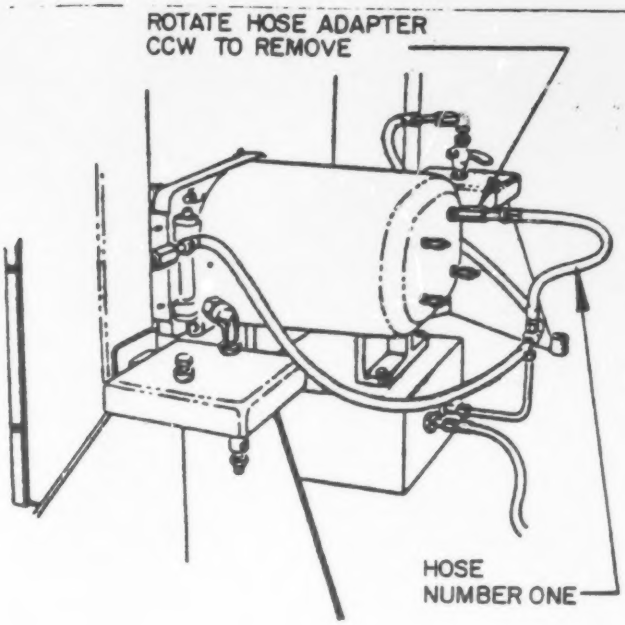

ROTATE HOSE ADAPTER
CCW TO REMOVE
HOSE
NUMBER ONE

Figure 8a.

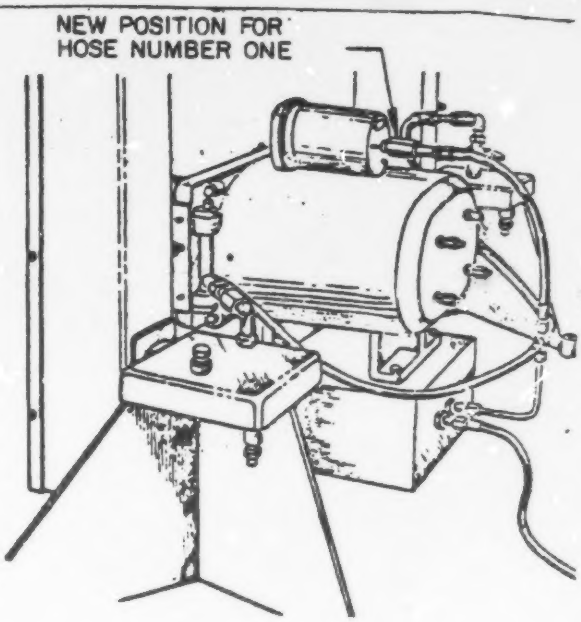

NEW POSITION FOR
HOSE NUMBER ONE

Figure 8b.

k. Remove hose number two from the upper fitting of the mercury manometer and secure it to the lower fitting, see figure 9. Be sure that the rubber "O" ring is in place and in good condition before making the connection.

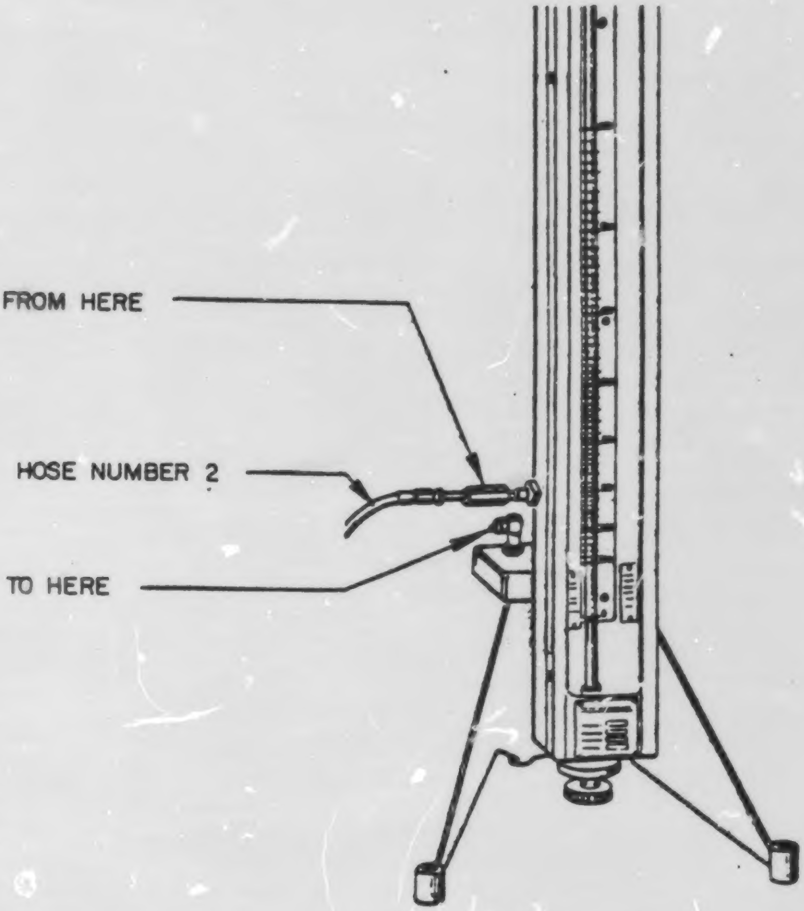

FROM HERE
HOSE NUMBER 2
TO HERE

Figure 9.

X

1216

l. Open the pressure source valve on the back of the workbench at least 2 complete revolutions counterclockwise but not more than 4.

m. Close the vent valve on the vacuum pressure panel.

n. This completes the preliminary set up of the test equipment. Careful observation of the completed set up will show that as you apply pressure (simulated Pt increases) to the airspeed indicator, you are also applying pressure to the water manometer and the mercury manometer, see figure 10.

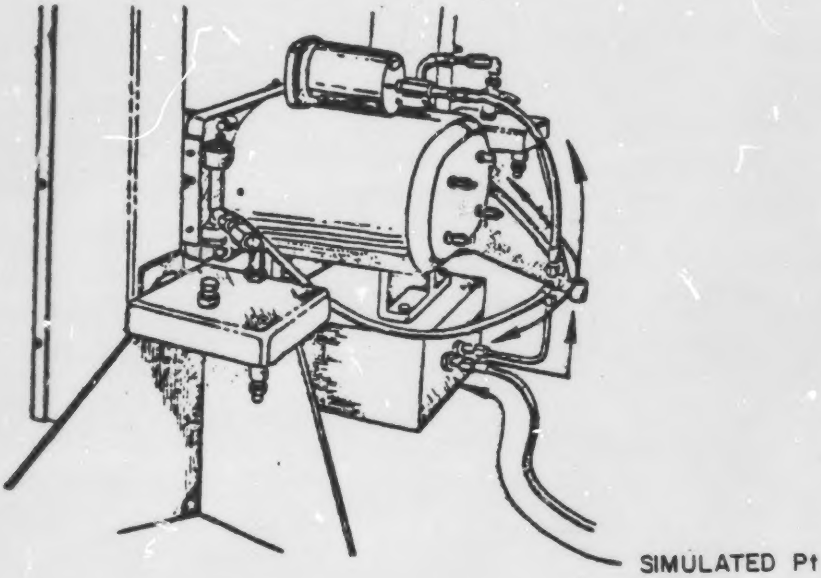


Figure 10.

2. Determination of scale error and friction error.

a. Since you have zeroed the manometers and selected the correct scales, the manometer may now serve as a master indicator for determining if the airspeed section of the indicator is in satisfactory condition. Since water is much lighter than mercury, the water manometer must be used with low pressures only. High pressures will cause the water to be pushed up and out the top of the glass tube making the manometer worthless as a master indicator. The mercury manometer is used with high pressures. When high pressures are used, the water manometer must be isolated or eliminated from the system. When and how to isolate the water manometer will be discussed in the following steps.

b. Slowly open the vac/press source valve on the vacuum pressure panel and allow the water to rise until the meniscus is aligned with the 60 knot increment on the scale of the water manometer. (Read through step c. before entering readings in table 1.)

(1) Read the indicator.

(2) Enter the reading in the column labeled "Before tapping", table 1.

(3) Tap the indicator gently.

(4) Read the indicator.

(5) Enter the reading in the column labeled "After tapping", table 1.

READINGS TAKEN UPSCALE - WATER MANOMETER								
Test points	Before tapping	After tapping	Scale error	Scale error tol.	Sat or unsat	Friction error	Friction error tol.	Sat or unsat
60				± 4.0			3.0	
120				± 2.0			3.0	
180				± 2.5			3.0	
*260				± 3.0			3.0	

*Read this test point from the mercury manometer.

Table 1.

c. If the water will not remain at the desired test point after you have closed the vac/press source valve, recheck your connections. If you cannot stop the water from dropping, open the vac/press source valve enough to maintain the desired test point.

d. Repeat step "b" and step "c" for each of the remaining test points in table 1. Enter your results in the appropriate column.

e. Compute the scale error and the friction error for each test point in table 1.

Note: (scale error) If the indicator's after tap reading is larger than the master indicator's test point (manometer reading), the scale error is plus or positive (+). If the indicator's after tap reading is smaller than the master indicator's test point (manometer reading), the scale error is minus or negative (-).

Note: (friction error) Friction error is the difference between what the indicator was reading before you tapped it (before tapping) and what it reads after you tapped it (after tapping).

Friction error never has a plus (+) or a minus (-) sign with it because you are not comparing the indicator's readings to the master indicator's (manometer) readings. Friction error compares the before tap and the after tap readings.

f. Compare the amount of scale error you recorded in the scale error column to the tolerance given for that test point. Record an "S" or a "U" for satisfactory or unsatisfactory.

g. Enter an "S" or a "U" for friction error by comparing it to the tolerance given for each test point.

h. The water manometer must remain at 260 knots until the downscale check. Therefore, close the pressure valve on the water manometer. The arm of the valve should be parallel to the surface of the workbench.

Caution: Be sure the water valve is shut off. If it is not, the water will be forced out of the top of the manometer. If this happens, the manometer has to be sent to the base shop for recalibration.

i. DID YOU TURN THE PRESSURE VALVE LOCATED ON THE WATER MANOMETER TO THE CLOSED POSITION (parallel to the surface of the workbench)?

yes _____ no _____

If your answer is no, then turn the valve to the closed position now.

j. Using the mercury manometer, continue upscale, stopping at each test point in table 2. Enter your results for each test point and compute the scale error and the friction error just as you did in table 1.

READINGS TAKEN UPSCALE - MERCURY MANOMETER								
Test points	Before tapping	After tapping	Scale error	Scale error tol.	Sat or unsat	Friction error	Friction error tol.	Sat or unsat
340				± 4.0			3.0	
420				± 5.0			3.0	
500				± 6.0			3.0	
580				± 6.0			3.0	
650				± 8.0			3.0	

Table 2.

k. Using the vent valve, located on the vacuum pressure panel, slowly release the pressure to allow the mercury to drop to each test point in table 3. Enter your results for each test point and compute the scale error and the friction error just as you did in tables 1 and 2.

READINGS TAKEN DOWNSCALE - MERCURY MANOMETER								
Test points	Before tapping	After tapping	Scale error	Scale error tol.	Sat or unsat	Friction error	Friction error tol.	Sat or unsat
580				± 6.0			3.0	
500				± 6.0			3.0	
420				± 5.0			3.0	
340				± 4.0			3.0	
260				± 4.0			3.0	

Table 3.

l. Open the pressure valve on the water manometer.

m. Using the water manometer and the vent valve, continue downscale, stopping at each test point in table 4. Enter your results for each test point and compute the scale error and friction error just as you did in tables 1 thru 3.

READINGS TAKEN DOWNSCALE - WATER MANOMETER								
Test points	Before tapping	After tapping	Scale error	Scale error tol.	Sat or unsat	Friction error	Friction error tol.	Sat or unsat
180				± 2.5			3.0	
120				± 2.0			3.0	
60				± 4.0			3.0	

Table 4.

n. Using the vent valve, decrease the pressure to zero

o. Close the pressure source valve on the back of the workbench.

p. Recheck your entries in tables 1 thru 4.

(1) In the scale error column you must have a plus (+) or minus (-) sign, the correct numerical difference between the test point and the indicator's after tap reading, and an "S" or a "U" according to the tolerance given for each test point.

(2) In the friction error column you must have the correct numerical difference between the before tap reading and the after tap reading and an "S" or a "U" according to the tolerance given for each test point. NEVER place a plus (+) or a minus (-) sign with friction error.

(3) After completion of this test, close the water valve on the water manometer.

MAXIMUM ALLOWABLE AIRSPEED SECTION

3. Determination of scale error and friction error.

a. Go to an A-1 barometer and find the local pressure in millimeters of mercury. Since the mercury manometer is graduated in centimeters of mercury, it will be necessary to convert the barometer's mmHg reading to cmHg by moving the decimal point one (1) place to the left.

(1) Example: 735.3 mmHg = 73.53 cmHg.

(2) Ask your instructor for the critical mach number to be used while performing the bench check. ENTER BOTH PIECES OF INFORMATION IN THE SPACES PROVIDED. ________cmHg. ________Critical mach number.

b. Disconnect the hose from the airspeed indicator. Reconnect the hose to the vacuum chamber. Check the "O" ring.

c. Place the indicator in front of you so you can see the mach number scale and the mach index marker.

> Note: The mach number scale and the mach index marker are for the use of the instrument man only. They are hard to see and purposely painted black so the pilot will not confuse them with the indicator's airspeed scale and pointer.

d. Remove the hex head Allen type dust cap from the rear of the indicator and turn adjustment screw found under the cap with a screwdriver until the mach index marker is aligned with the critical mach number (M crit) given to you by your instructor. Replace cap after adjustment is made.

e. Turn the maximum allowable airspeed pointer adjustment on the front of the indicator's case fully counterclockwise to insure proper reading of the maximum allowable pointer. Do not overtorque the screw. Damage to the pointer linkage may result.

f. At the bottom of each altitude scale (scales labeled "Read altitude in thousands of feet") you will find a section of the altitude scale marked off in centimeters of mercury.

(1) Using the scale select knob, rotate the scales of the manometer until you find an altitude scale containing a centimeter section whose range includes the local pressure. If it does not appear on one scale, then rotate the scales until the next scale is in view. You will find that the scale you now have in view begins where the previous

scale left off. Figure 11 shows the correct position of the scale for a local pressure of 73.8 centimeters of mercury. Rotate the zero adjustment screw until the local pressure is in line with the mercury meniscus.

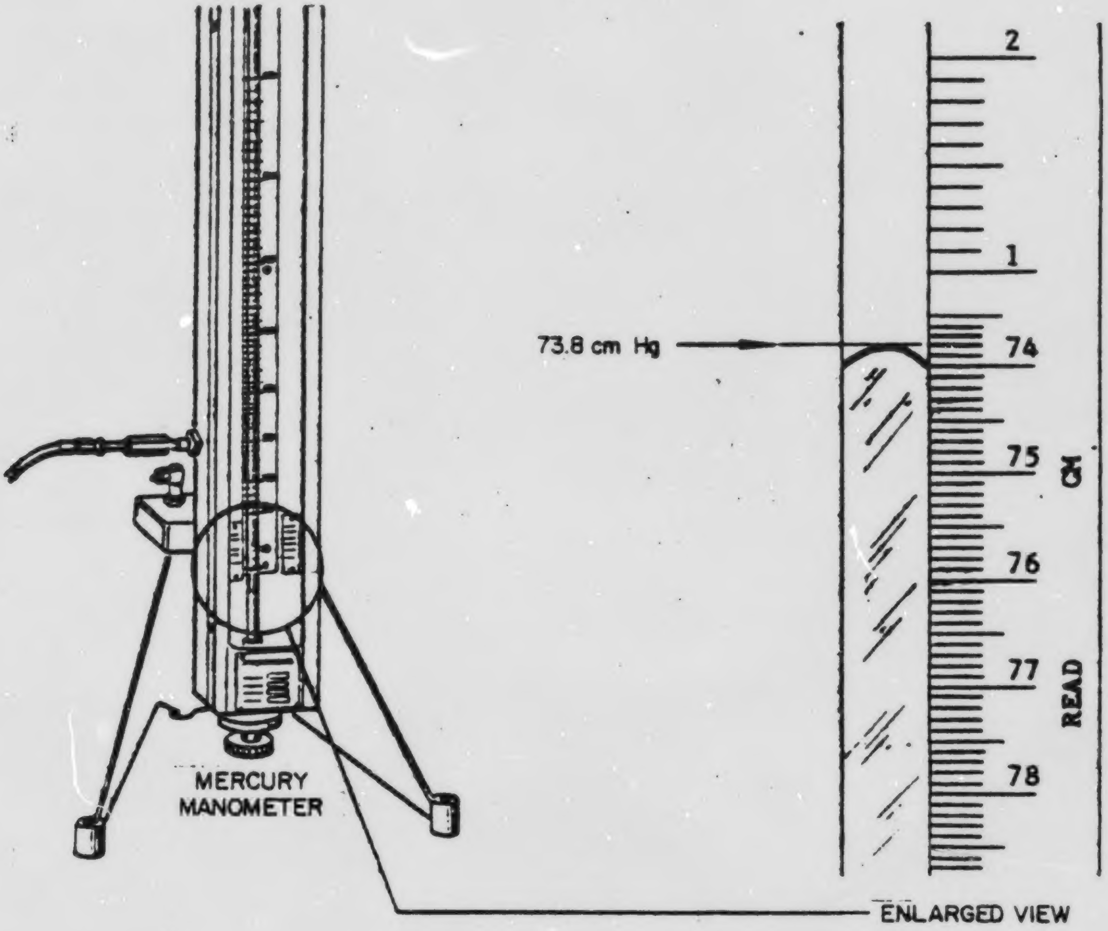


Figure 11.

g. Disconnect the hose from the lower (pressure) fitting on the mercury manometer and reconnect the hose to the top (vacuum) fitting on the manometer. Check the "O" ring.

h. Place the indicator in the vacuum chamber so it can be easily viewed through one of the two windows in the vacuum chamber door. Close the door and tighten the wing nuts. Be sure that you tighten the two wing nuts that are next to the door's hinge first; then tighten the remaining two wing nuts. This will insure a tight seal between the door and the vacuum chamber.

i. Locate the M crit assigned to you in table 5. Directly below the M crit you have been assigned, you will find a list of maximum allowable pointer readings for specific altitudes. Copy the list of knots into the spaces in the column labeled "pointer position" of table 6.

CRITICAL MACH NUMBER (M crit)				
	.6	.7	.8	.9
Altitude (feet)	Airspeed (knots)	Airspeed (knots)	Airspeed (knots)	Airspeed (knots)
0	397	463	530	595
10,000	333	390	448	507
20,000	275	323	373	423
30,000	223	262	303	346
40,000	177	209	242	277
50,000	140	165	192	220

All scale error tolerances are ± 4.0 knots.
All friction error tolerances are 3.0 knots.

Table 5.

Altitude (feet)	Pointer position (knots)	Before tapping	After tapping	Scale error	S/U	Friction error	S/U
10,000							
20,000							
30,000							
40,000							
50,000							

All scale error tolerances are ± 4.0 knots.
All friction error tolerances are 3.0 knots.

Table 6.

j. CHECK TO BE SURE THAT THE WATER VALVE ON THE WATER MANOMETER IS CLOSED.

k. Close the vent valve on the vacuum chamber.

l. Open the vacuum source valve at the back of the workbench.

m. Open the vac/press source valve on the vacuum pressure panel and slowly run the mercury up to each test point in table 6. Complete the before tap, after tap, scale error, and friction error entries for table 6.

n. After you have completed the 50,000 foot test point, DO NOT LOWER THE MERCURY but proceed to the "Hysteresis test."

4. Hysteresis test (metal fatigue of the aneroid).

a. Open the vent valve and slowly drop the mercury to the 30,000 foot test point. Allow the mercury to remain at this test point for a period of five minutes.

b. After the five minute waiting period, tap the vacuum chamber and record the reading in table 7 in the column labeled "Reading at end of time period."

Test points (feet)	Time period (min.)	Upscale reading (knots)	Reading at end of time period (knots)	Error	S/U	Tolerance
30,000	5					± 2 knots
10,000	1					± 2 knots

Table 7.

c. Take the after tap reading of the indicator at 30,000 feet from table 6 and enter this figure in the column labeled "Upscale reading" in table 7.

d. The difference between these two figures is the hysteresis error or metal fatigue of the aneroid and should be recorded in the error column.

e. Hysteresis error must be labeled as a plus (+) error if the reading after the time period is larger than the upscale reading and a minus (-) error if the reading after the time period is smaller than the upscale reading.

f. An "S" for satisfactory and a "U" for unsatisfactory should also be placed in the S/U column according to the tolerances listed.

g. Again open the vent valve and lower the mercury to 10,000 feet. Allow the mercury to remain at this test point for a period of one minute.

h. Determine and label the error just as you did for the 30,000 foot test point.

5. Lab station clean up.

a. Using the vent valve, slowly vent off all of the remaining vacuum.

b. Open the vacuum chamber door and remove the indicator.

c. Close the chamber door. Allow the wing nut bolts to hang loose.

d. Replace the dust cap on the back of the indicator.

e. Replace all dust caps that were removed during the preliminary set up of the lab station.

f. Refer to figure 1 of this workbook to review the hose and dust cap positions. Your lab station should now look like figure 1.

g. Ask your instructor to check your work and secure your lab station.

Work checked.

Lab station secure

____
Instructor's Signature

Section 4. OPERATIONAL INSPECTION AND TROUBLESHOOTING OF THE PITOT-STATIC SYSTEM

EQUIPMENT

	Basis of Issue
MB-1 Tester	1/student
Pitot-Static System Trainer	1/student
Screwdriver	1/student

PROCEDURE

Perform the following checks, and fill in the blanks with the correct information.

Caution: Remove all jewelry and observe all ground safety rules.

OPERATIONAL INSPECTION CHECKS

1. MB-1 Pitot-Static Tester Leak Check.

Note: This check must always be performed before the tester is used.

a. MB-1 pitot leak check.

Caution: To prevent damage to the valve seats, never tighten the needle valves more than finger tight.

(1) Make sure all needle valves are closed finger tight.

(2) Pump the pressure tank to 50" Hg.

(3) Place one end of the rubber hose supplied with tester on the pitot pressure hose connector and the other end over one end of the vacuum pump handle as a plug.

Caution: Never remove the hose until all pressure is vented out of the hose.

(4) Slowly open the "pitot source" valve and run the master airspeed indicator upscale to 600 knots.

(5) Close the valve *finger* tight when the indicator reaches 600 knots.

(6) Time the airspeed indicator for one minute and enter the amount of leakage in this blank. ________________________________

(7) The allowable leakage for the tester is 2 knots per minute. Is this check satisfactory or unsatisfactory? Enter S or U in this blank. ____________

(8) *Slowly* open the pressure vent valve and release all pressure which allows the airspeed indicator to move down the scale toward zero.

b. [illegible]-1 static leak check.

(1) Make sure all needle valves are closed *finger* tight.

(2) Pump the vacuum tank up to 20" Hg.

(3) Remove the rubber hose from the pitot side of the tester, and connect it in the same way to the static side.

(4) Slowly open the "static source" valve and run the master airspeed indicator to 435 knots.

(5) Close the static source valve when the master airspeed indicator reaches 435 knots and time it for one minute. Enter the amount of leakage in this blank. ____________________

(6) The allowable leakage for the tester is four knots per minute. Is this check satisfactory or unsatisfactory? Enter an S or U in this blank. __________

(7) Slowly open the vacuum vent valve and release the vacuum which allows the airspeed indicator to move down the scale toward zero.

(8) Remove the vacuum hose.

2. Pitot Static System (Trainer Indicators) Check.

a. Check indicators for security of mounting (S or U) ______.

If U, explain ____.

b. Check the condition of the cover glass (S or U) ________.

If U, explain ____.

c. Check the indicators' slippage and range marks (S or U)

________. If U, explain ____.

3. Pitot Static System (Trainer) Check.

a. Airspeed check on trainer.

(1) Close all pitot valves finger tight on the MB-1 tester.

(a) Open static valves.

(2) Connect one end of the hose to the pitot pressure hose connection on the MB-1 tester, and the other end to the pitot tube rubber adapter.

(3) Check the pressure gage. If it does not indicate 50" Hg, pump it up until it indicates 50" Hg.

Note: Call the instructor.

(4) Slowly open the "pressure source" valve and run the master airspeed indicator on the tester to 600 knots.

(5) Close the "pressure source" valve when the master airspeed indicator reaches 600 knots.

Note: The trainer airspeed indicator should agree with the master airspeed indicator within 8 knots.

(6) Time the master airspeed indicator for one minute and enter the amount of leakage. __________ knots per min.

(7) The allowable leakage for the trainer is 2 knots per minute, plus the leakage of the MB-1 tester as found in paragraph 1.a.(6). Is this check S or U? Enter S or U in this space. __________

(8) Open the pressure vent valve and slowly release all pressure which will allow the airspeed indicator to move down the scale toward zero.

b. Altitude (altimeter) check on trainer.

(1) Close all static valves finger tight on the MB-1 tester.

(2) Remove the hose from the pitot system, and the pitot tube adapter.

(3) Connect the hose to the vacuum (static) pressure hose connection and the other end to the adapter for the static system.

(4) Using the vacuum pump, evacuate the vacuum tank to 20" Hg.

Note: The above step (4) has to be repeated during the following check. To replenish the vacuum, close the "vacuum source" valve and evacuate the tank again to 20" Hg.

Caution: DO NOT EXCEED 5,000 FEET-PER-MINUTE ON THE RATE OF CLIMB INDICATOR DURING THE FOLLOWING CHECK.

(5) Using the baro set knobs, set both the altimeters, one on the MB-1 tester and the one on the trainer, to 740'. (Elevation of Chanute AFB.)

Note: Call the instructor.

(6) Slowly open the "vacuum source" valve and run the master altimeter up to 10,000' altitude and close the source valve.

(7) The altimeter on the trainer should indicate within 160' of the master altimeter on the trainer. Indicate if satisfactory by circling either yes or no.

(8) Time the master altimeter for one minute and enter the amount of leakage in the space provided. ________ feet per minute.

(9) The allowable leakage for the system is 100 feet per minute. Indicate if satisfactory by circling either yes or no.

(10) Lower the altimeters to 740 feet altitude by slowly opening the vacuum vent valve. Remember, do not exceed 5,000 FPM on the vertical velocity indicator.

Note: Stop Here: Call the instructor.

c. Troubleshooting.

Now that you know how to perform an operational check on the pitot-static system, the next step is troubleshooting the system and the instruments that make up the system. The operational check will be performed each time the system or the instruments are checked during a periodic inspection. Care and close attention must be given to each instrument in the system in order to arrive at a meaningful conclusion and determination of a malfunction.

We know that the system as we learned in 3ABR32531-PT-301 has pitot pressure applied only to the airspeed indicator and static pressure applied to all three indicators. Knowing this will make the analysis of a malfunction of the system or instrument easier.

First of all let's review some possibilities: A cracked instrument case or loose cover glass will cause a leak in either the pitot system or static system. Stripped instrument or manifold fittings will cause leaks. Cracked or weathered instrument hoses can cause leaks, as well as cracked rigid tubing.

Secondly, mechanical failures such as ruptured aneroids or diaphragms and broken or worn mechanical linkages will cause malfunctions. A special malfunction is brought out by a cracked or broken thermos container in the vertical velocity indicator. The container in conjunction with the diffuser valve creates differential pressure to be measured and turned into pointer movement of the indicator.

d. Completion of tests.

(1) Release all pressure or vacuum remaining in the tanks. Open the vent valves and then slowly open the source valves.

(2) Store all accessories in the tester and put the equipment back in the cabinet.

(3) Review the procedure for performing an operational inspection check on the pitot static system. If you know how to perform an operational inspection check, proceed to the next section.

TROUBLESHOOTING THE PITOT-STATIC SYSTEM

The last page of this workbook is a SAMPLE AFTO Form 781A, Maintenance Discrepancy and Work Document. This form will be used to record the malfunctions of the trainer. All entries will be made in pencil.

Note: Have your instructor put in problem #1 on your assigned trainer.

Problem 1

1. Complete a system operational check. (Read entire problem before continuing.)

a. Apply pressure to the trainer and run the airspeed indicator (Master) to 450 knots. (Leave static pressure vent valve open.) Observe airspeed indicator for malfunction. Allow pressure to bleed off slowly.

b. Apply static pressure to the trainer and run the altimeter (Master) to 2,500 feet. (DO NOT EXCEED 5,000 FPM ON THE VERTICAL VELOCITY INDICATOR.) Observe all three indicators for malfunction.

2. Record the malfunction/s noted during the operational check on the 781A in the #1 DISCREPANCY block. State the operation of all three (3) flight instruments.

3. Listed below are the ten (10) possible malfunctions. Select the one that could cause problem #1 and record this information in the CORRECTIVE ACTION block on the 781A.

Note: Observe the operation of all three (3) flight instruments on the trainer (as in EXAMPLE). Watch pointers for no movement, indications of leaks, etc. Zero the vertical velocity indicator.

1230

EXAMPLE

SYM	DATE DISCO / /	WDC	JCN	TAG NO	CF TO 781A P I	DATED / / /	TRANSFERRED TO 781K DATE / /	TRANSFERRED BY

DISCREPANCY		CORRECTIVE ACTION
Pitot -	Airspeed	
	Altimeter - inop	Stripped pitot fitting on the
Static -	Airspeed - leaking	vertical velocity indicator.
	Vertical Velocity - normal	
		DATE CORRECTED / /

ON	DISCOVERED BY	CORRECTED BY	INSPECTED BY

Problem 2

1. Repeat the procedure for an operational check as in problem #1.

2. Select one of the ten (10) malfunctions that could cause problem #2 and enter in the CORRECTIVE ACTION block on the 781A.

Problem 3

1. Repeat the procedure for an operational check as in problem #1.

2. Select one of the ten (10) malfunctions that could cause problem #3 and enter in the CORRECTIVE ACTION block on the 781A.

Problem 4

1. Repeat the procedure for an operational check as in problem #1.

2. Select one of the ten (10) malfunctions that could cause problem #4 and enter in the CORRECTIVE ACTION block on the 781A.

POSSIBLE MALFUNCTIONS

Note: There may be more than one possible malfunction. Choose one of the correct malfunctions.

1. Case leak of the altimeter indicator.

2. Broken thermos container in the vertical velocity indicator.

3. Stripped pitot fitting on the vertical velocity indicator.

4. Case leak of the vertical velocity indicator.

1262

5. Ruptured diaphragm in the vertical velocity indicator.
6. Stripped pitot fitting on the airspeed indicator.
7. Clogged static openings on the pitot-static tube.
8. Broken mechanical linkage in the altimeter indicator.
9. Case leak in the airspeed indicator.
10. Clogged pitot opening of the pitot-static tube.

1232

PAGE OF PAGES

DATE FROM	TO	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO.
04/04/74	04/04/74	A1C Adams	3345th	Lab Station		Pitot-Static Tra

SYM	DATE DISCO	WDC	JCN	TAG NO	CF TO 781A DATED	TRANSFERRED TO 781K DATE	TRANSFERRED BY
	/ /				P 1 / /	/ /	

DISCREPANCY	CORRECTIVE ACTION
#1	
	DATE CORRECTED / /

ON	DISCOVERED BY	CORRECTED BY	INSPECTED BY

SYM	DATE DISCO	WDC	JCN	TAG NO	CF TO 781A DATED	TRANSFERRED TO 781K DATE	TRANSFERRED BY
	/ /				P 1 / /	/ /	

DISCREPANCY	CORRECTIVE ACTION
#2	
	DATE CORRECTED / /

ON	DISCOVERED BY	CORRECTED BY	INSPECTED BY

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	TRANSFERRED BY
	/ /				/ /	/ /	

DISCREPANCY	CORRECTIVE ACTION
#3	
	DATE CORRECTED / /

ON	DISCOVERED BY	CORRECTED BY	INSPECTED BY

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	TRANSFERRED BY
	/ /				P 1 / /	/ /	

DISCREPANCY	CORRECTIVE ACTION
#4	
1264	
	DATE CORRE D / /

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AFTO FORM MAY 74 781A **MAINTENANCE DISCREPANCY AND WORK DOCUMENT** PREVIOUS EDITION

PROGRAMMED TEXT
3ABR32531-PT-302
3ABR32632B-PT-402

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionics Systems Specialist

PRESSURE TEMPERATURE TEST SET TTU-205C/E

25 April 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR32531, Avionics Instrument Systems Specialist course, and the 3ABR32632B, Integrated Avionics Systems Specialist course. The text was validated with 20 students in the subject courses. At least 90% of the students achieved the stated objective. The average time to complete the text was one hour and seven minutes.

OBJECTIVES

After completing the programmed text and given a workbook and a TTU-205C/E Pressure Temperature Test Set, each student will perform a:

1. Preoperational check of the TTU-205C/E, Pressure Temperature Test Set.

2. Leak check of the TTU-205C/E, Pressure Temperature Test Set.

Items 1 and 2 above will be performed to a minimum accuracy of 100% of workbook procedures.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading the information in each frame, you are asked to select an answer or make an entry that shows that you understand the information in that frame. Check the accuracy of your answers by looking after each succeeding frame. If you selected the correct response, proceed to the next frame, however, if your answer was incorrect, you should restudy that frame before moving on to the next frame. DO NOT HURRY.

Supersedes 3ABR32531-PT-303, 17 March 1975, and3ABR32632B-PT-401A, 23 September 1974.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC-W - 200; TTVSR - 1

In recent years the need for an accurate and versatile pneumatic test set became evident with modern aircraft and avionics equipment. The old MB-1 Field Tester works fine on pressure operated flight instruments, but its range was limited and its accuracy questionable. For this reason, the TTU-205C/E Pressure-Temperature Test Set was built.

The TTU-205C/E is used to provide flight line and/or depot level support of aircraft systems requiring pneumatic inputs.

The purpose of the TTU-205C/E is to supply accurate inputs of pitot (P_t) and static (P_s) pressures and temperatures. Provision is also made for stimulating the total temperature probe input to an air data computer system.

Circle the number of the most correct statement that completes the statement below.

The purpose of the TTU-205C/E Pressure-Temperature Test Set is to supply accurate inputs of:

1. pitot pressure only.

2. pitot and static pressures only.

3. pitot and static pressures and temperature to using equipment.

4. pitot and dynamic pressures and temperature to using equipment.

1236

Frame 2

The TTU-205C/E Test Set produces stable static pressures simulating altitudes from -1,500 feet to +80,000 feet. The test set also produces stable pitot pressures simulating airspeeds from 50 knots to 1,000 knots, with a total temperature simulated output of -99°C through +430°C.

The power requirements are 115 VAC, 400-Hz single phase (Ø).

Circle the letters of the responses that correctly complete the statements below.

1. The static pressure range of the TTU-205C/E Test Set is:
   a. 0' to +80,000 feet.
   b. -1,500 to +80,000 feet.
   c. -1,500 to +120,000 feet.
   d. -1,000 to +80,000 feet.
2. The pitot pressure range of the TTU-205C/E Test Set is:
   a. 50 to 650 knots.
   b. 50 to 750 knots.
   c. 50 to 850 knots.
   d. 50 to 1,000 knots.
3. The TTU-205C/E has a total temperature output with a range of:
   a. -50°C to +375°C.
   b. -99°C to +430°C.
   c. -50°C to +350°C.
   d. -70°C to +385°C.
4. The power requirement for the TTU-205C/E is:
   a. 28 VDC.
   b. 115 VAC, 400Hz, 3Ø
   c. 115 VAC, 60Hz, 1Ø
   d. 115 VAC, 400Hz, 1Ø

Answers to Frame 1: 3

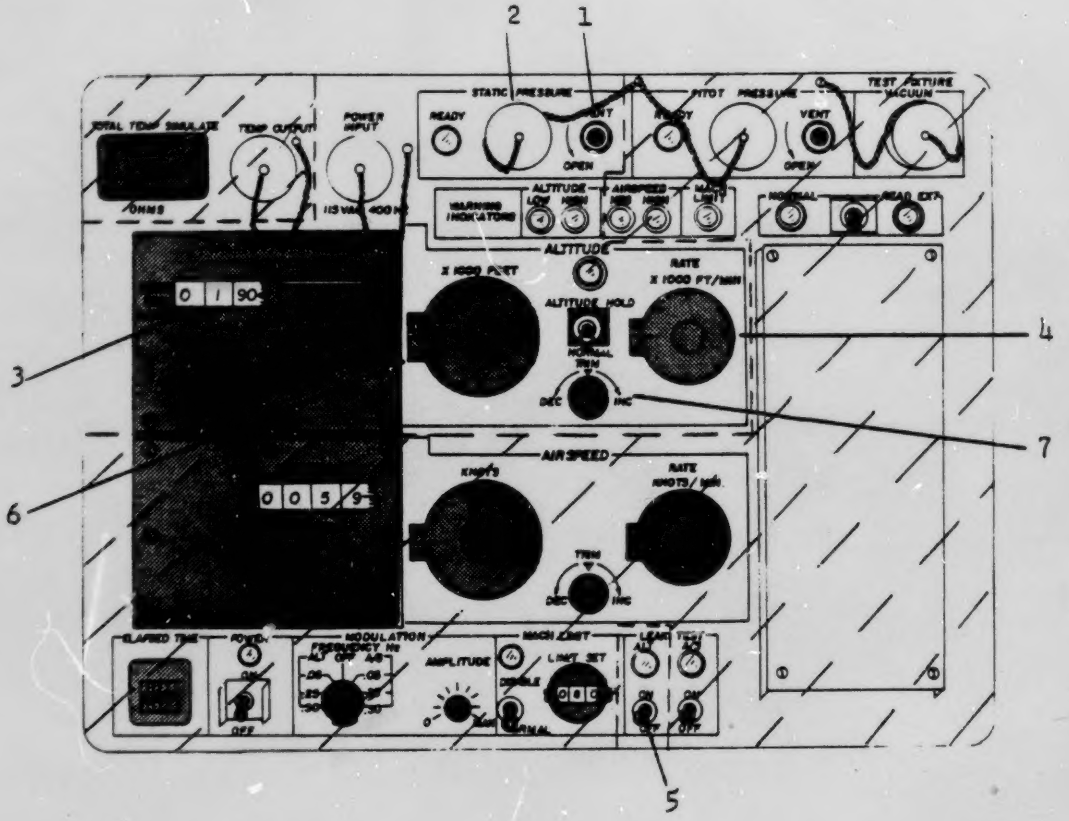

2
1
3
4
7
6
5
STATIC PRESSURE
READY
VENT
OPEN
PITOT PRESSURE
READY
VENT
OPEN
TEST FIXTURE VACUUM
TOTAL TEMP SIMULATE
OHMS
TEMP OUTPUT
POWER INPUT
115 VAC 400 HZ
WARNING INDICATORS
ALTITUDE
LOW
HIGH
AIRSPEED
LOW
HIGH
MACH LIMIT
NORMAL
READ EXT
ALTITUDE
X 1000 FEET
RATE X 1000 FT/MIN
ALTITUDE HOLD
NORMAL
TRIM
DEC
INC
0 1 90
AIRSPEED
KNOTS
RATE KNOTS/MIN
TRIM
DEC
INC
0 0 5 9
ELAPSED TIME
POWER
ON
OFF
MODULATION
FREQUENCY HZ
ALT
OFF
A/S
AMPLITUDE
MACH LIMIT
LIMIT SET
DISABLE
NORMAL
LEAK TEST
ON
OFF
ON
OFF

Figure 1.

All controls and indicators are located on a single panel as shown in figure 1. The test set will be covered in sections. The altitude or Ps section, as shown in the clear (not covered with dotted lines), will be discussed first. The more important controls and indicators are numbered in figure 1.

Number 1. Ps VENT VALVE - Used to bleed off Ps pressure, during shutdown after completion of checks. Normally closed (fully clockwise).

Number 2. Ps COUPLING - Ps output of the test set. The coupling is color coded. The coupling allows for a snap-on connection of the Ps hose.

Number 3. ALTITUDE COUNTER - Indicates Ps pressure being applied, in feet of altitude above or below sea level.

Number 4. ALT RATE X 1000 FEET/MIN CONTROL - Used to select the rate of changing Ps pressure in thousands of feet-per-minute.

Frame 3 (Continued)

Number 5. Ps LEAK TEST SWITCH - Used for leak checking the static system. When actuated, it traps existing Ps pressure in the system under test.

Number 6. ALTITUDE X 1000 FEET CONTROL - Used to set in the amount of altitude (Ps) desired for the test. Provides a coarse control of Ps pressure.

Number 7. TRIM CONTROL KNOB - Provides for fine adjustment of altitude (Ps pressure).

Match the numbers of the components of the TTU-205C/E by placing the letter of the purpose/definition in the space provided with the correct component.

COMPONENT

_____1. Ps Vent Valve

_____2. Ps Coupling

_____3. Altitude Counter

_____4. Alt Rate X 1000 Ft/Min

_____5. Ps Leak Test Switch

_____6. Altitude X 1000 Ft Control

_____7. Trim Control Knob

PURPOSE/DEFINITION

a. Used to set in the amount of altitude (Ps) desired for the test. Provides a coarse control of Ps pressure.

b. Provides for fine adjustment of Ps pressure.

c. Indicates Ps pressure being applied, in feet of altitude, above or below sea level.

d. Used to bleed off Ps pressure.

e. Used to select the rate of changing Ps pressure.

f. Used for leak checking the static system.

g. Allows for snap-on connection of the Ps hose.

Answers to Frame 2: 1. b 2. d 3. b 4. d

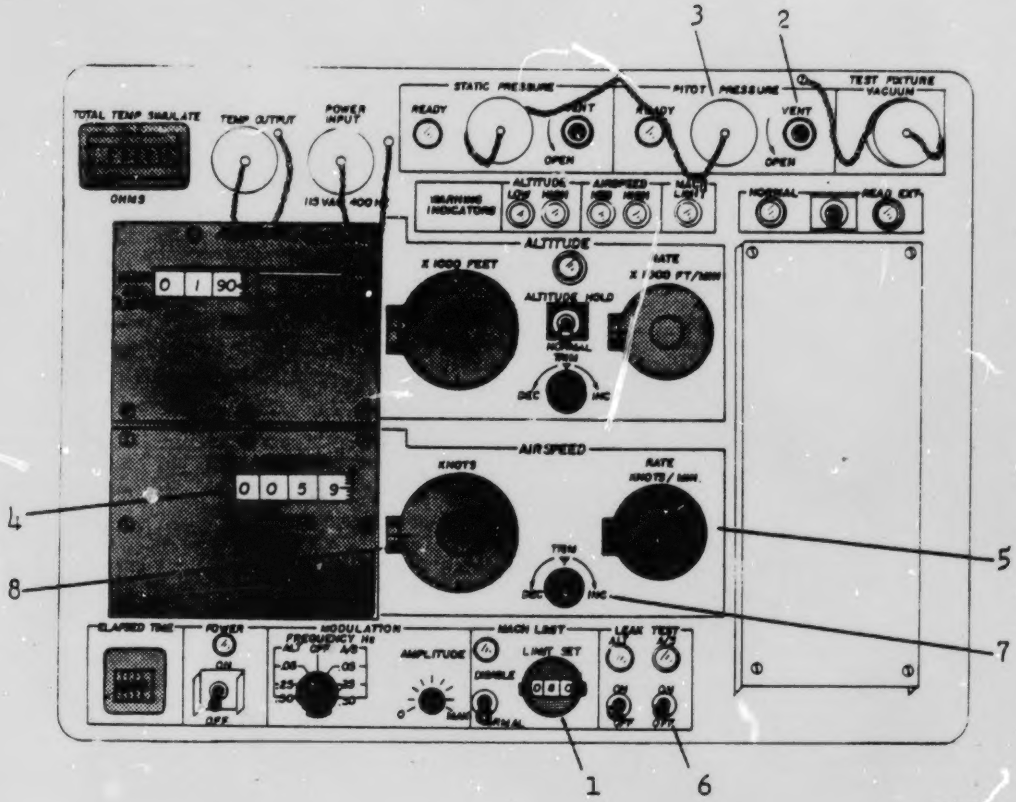

3
2
STATIC PRESSURE
PITOT PRESSURE
TEST FIXTURE VACUUM
TOTAL TEMP SIMULATE
TEMP OUTPUT
POWER INPUT
READY
VENT
OPEN
OHMS
115 VAC 400 Hz
WARNING INDICATORS
ALTITUDE LOW HIGH
AIRSPEED LOW HIGH
MACH LIMIT
NORMAL
READ EXT
0 1 90
ALTITUDE
X 1000 FEET
RATE X 1000 FT/MIN
ALTITUDE HOLD
NORMAL TRIM
DEC INC
AIRSPEED
KNOTS
RATE KNOTS/MIN
TRIM
0 0 5 9
4
8
5
7
ELAPSED TIME
POWER
ON
OFF
MODULATION
FREQUENCY Hz
ALT OFF A/S
AMPLITUDE
MACH LIMIT
LIMIT SET
DISABLE
NORMAL
LEAK TEST
ALT A/S
1
6

Figure 2.

In the P_t section of the TTU-205C/E most of the components are similar to the Ps section. In figure 2, the most important components are shown, (1 through 8). These components are listed below with their purpose/definition.

Number 1. MACH LIMIT CONTROL - Used to safeguard against overpressurizing the system under test. This control provides an adjustment for setting in the maximum mach you want the tester not to exceed. The range is 0.8m to 3.0m.

Number 2. P_t VENT VALVE - Used to bleed off Pt pressure after completion of test. Normally closed.

Number 3. P_t COUPLING - This is the Pt output. Supplies total pressure to the system being tested.

Number 4. AIRSPEED KNOTS COUNTER - Indicates the amount of total pressure (P_t) applied in knots of airspeed.

Number 5. AIRSPEED RATE KNOTS/MIN - (Airspeed Rate Knots Control) - Used to control the rate of P_t applied to a system.

Frame 4 (Continued)

Number 6. P_t LEAK TEST SWITCH - Used for leak checking the pitot system. When actuated, it closes the P_t isolation valve, trapping existing P_t pressure in the system under test.

Number 7. AIRSPEED TRIM CONTROL - Used for fine adjustment of P_t pressure (Airspeed Knots).

Number 8. AIRSPEED KNOTS CONTROL - Provides coarse control of P_t pressure.

Match the numbers of the components of the TTU-205C/E to the correct purpose or definition by placing the letter of the purpose/definition in the space provided with the correct components.

COMPONENT

_____1. Mach Limit Control

_____2. P_t Vent Valve

_____3. P_t Coupling

_____4. Airspeed Knots Counter

_____5. Airspeed Rate Knots

_____6. P_t Leak Test Switch

_____7. Trim Control

_____8. Airspeed Knots Control

PURPOSE/DEFINITION

a. Provides coarse control of P_t pressure.

b. Used to control the rate of P_t applied to a system.

c. This is the P_t output. Supplies total pressure to the system being checked.

d. Used to limit mach output.

e. Used for fine adjustment of P_t pressure.

f. Indicates the amount of P_t applied in knots of airspeed.

g. Used to leak check the P_t system.

h. Used to bleed off P_t pressure after completion of test.

Answers to Frame 3:

__d__1. __g__2. __c__3. __e__4. __f__5. __a__6. __b__7.

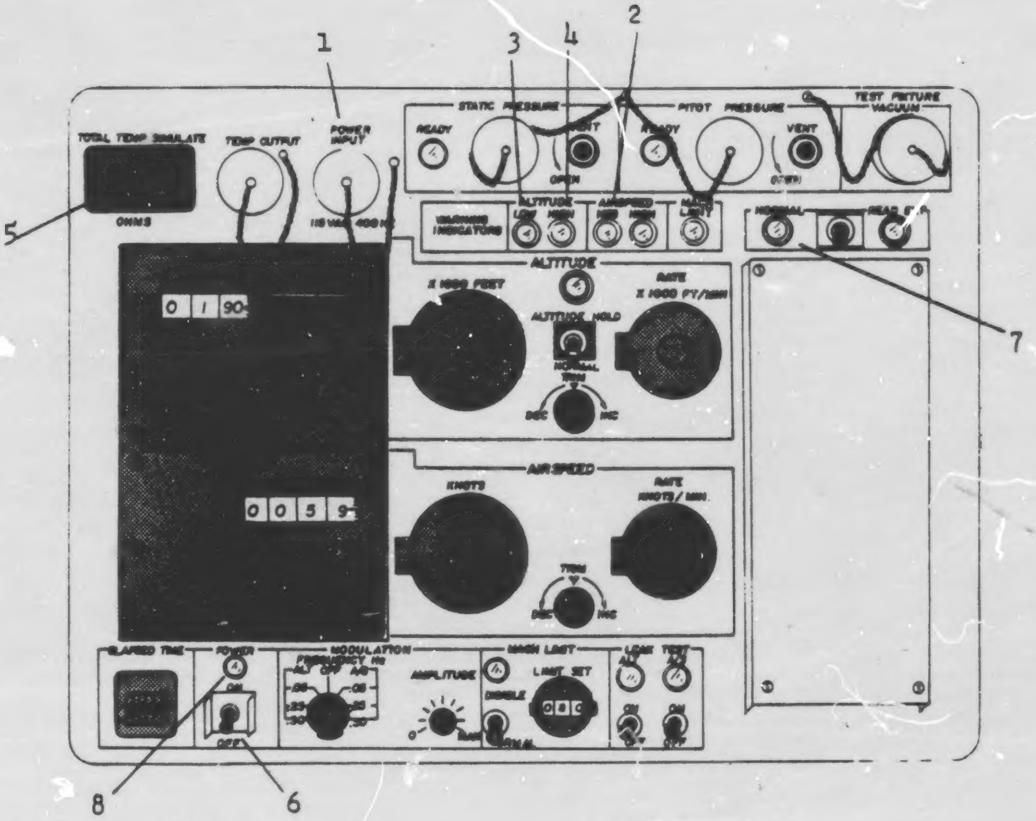

1
2
3
4
5
6
7
8
TOTAL TEMP SIMULATE
OHMS
TEMP OUTPUT
POWER INPUT
115 VAC 400 HZ
STATIC PRESSURE
READY
VENT
OPEN
PITOT PRESSURE
READY
VENT
OPEN
TEST FIXTURE VACUUM
WARNING INDICATORS
ALTITUDE
LOW
HIGH
AIRSPEED
LOW
HIGH
NORMAL
ALTITUDE
X 1000 FEET
RATE X 1000 FT/MIN
ALTITUDE HOLD
NORMAL
TRIM
DEC
INC
AIRSPEED
KNOTS
RATE KNOTS/MIN.
TRIM
DEC
INC
0 1 90
0 0 5 9
ELAPSED TIME
POWER
ON
OFF
MODULATION
FREQUENCY HZ
AMPLITUDE
LIMIT SET
DISABLE
LEAK TEST
ON
OFF

Figure 3.

In figure 3, the last of the components that you will use are shown. Most of these components are dealing with power or operating limit controls.

These components are listed below with their purpose or definition.

Number 1. POWER INPUT - Power connector for 115 VAC, 400-Hz, 1-0.

Number 2. AIRSPEED LOW LIMIT WARNING LAMP - Indicates Pt pressure is below the 50 knots low limit.

Number 3. ALTITUDE LOW LIMIT WARNING LAMP - Indicates Ps pressure is below the -1500 feet low limit.

Number 4. ALTITUDE HIGH LIMIT WARNING LAMP - Indicates Ps pressure is above the +80,000 feet high limit.

Number 5. TEMPERATURE SIMULATOR CONTROL - Provides a simulated input of total temperature. It has a range of -99°C to +430°C.

Number 6. POWER OFF/ON SWITCH - Switches power "ON" on the test set.

Frame 5 (Continued)

Number 7. NORMAL LAMP - Indicates that power is applied to the pump.

Number 8. CONTROL LAMP - Indicates that power is applied to the internal circuits.

Match the number of the component of the TTU-205C/E by placing the letter of the purpose/definition in the space provided with the correct component.

COMPONENT

_____1. Power Input

_____2. Airspeed Low Limit Lamp

_____3. Altitude Low Limit Lamp

_____4. Altitude High Limit Lamp

_____5. Temp Simulator Control

_____6. Power Off/On Switch

_____7. Normal Lamp

_____8. Control Lamp

PURPOSE/DEFINITION

a. Provides a simulated input of total temperature range -99°C to +430°C.

b. Indicates Ps pressure below the -1500 ft low limit.

c. Indicates power applied to internal circuits.

d. Indicates Ps pressure is above the +80,000 feet high limit.

e. Indicates power applied to the pump.

f. Indicates Pt pressure is below the 50 knots low limit.

g. Switches power to the test set.

h. Power connector for 115 VAC, 400Hz, 1Ø.

Answers to Frame 4:

d 1. h 2. c 3. f 4. b 5. g 6. e 7.

a 8.

Frame 6

Now that you have an understanding of the control panel's components and controls, you will go to the lab and perform a leak check on the TTU-205C/E test set. The procedures for this check will be outlined in the workbook provided, which you must follow exactly. After completion of the leak check, follow the shutdown procedures outlined in the workbook.

NO RESPONSE REQUIRED

Answers to Frame 5:

h 1. f 2. b 3. d 4. a 5. g 6. e 7. c 8.

APPRAISAL

1244

PROGRAMMED TEXT
3ABR32531-PT-302A

Technical Training

Avionics Instrument Systems Specialist

AUTOMATIC ALTITUDE REPORTING EQUIPMENT (AIMS)

11 December 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

1276

1245

FOREWORD

This programmed text was designed for use in the 3ABR32531, Avionics Instrument Systems Specialist course and the 3ABR32632B, Integrated Avionic Systems Specialist course. The text was validated with 31 students in the subject courses. At least 90% of the students achieved the stated objectives. The average time to complete the text was two hours and fifty-three minutes.

OBJECTIVES

1. Without references, identify facts pertaining to the purpose, operation and/or characteristics of automatic altitude reporting systems with a minimum accuracy of 75%.

2. Without references, identify facts pertaining to troubleshooting an automatic altitude reporting system with a minimum accuracy of 75%.

INSTRUCTIONS

This programmed text presents information in small steps called frames. After reading the information in each frame, you are asked to select an answer or make an entry that shows that you understand the information in that frame. Upon completion of this programmed text you will be required to take an appraisal which is designed to test your knowledge of the information in this text. If you do not understand any part of this programmed text check with your instructor before proceeding on to the next frame. TAKE YOUR TIME, DO NOT RUSH.

Supersedes 3ABR32531-PT-302A, 3ABR32632B-PT-402A, 26 October 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360TCHTG/TTGU-F - 200; TTVSA - 1

1277

AUTOMATIC ALTITUDE REPORTING SYSTEMS (AIMS)

Frame 1

In the past 25 years, air traffic has increased at an alarming rate. This has created problems in keeping aircraft at separate altitudes to avoid mid-air collisions and also in keeping aircraft at safe altitudes above the terrain. The AIMS system was developed for all aircraft so that better control could be maintained over today's heavy air traffic.

AIMS is derived from:

A - Air Traffic Control Radar Beacon System

I - Identification Friend or Foe (IFF)
(Radio - Receiver-Transmitter set called a transponder in this text)

M - Mark 12 System

S - System

Automatic altitude reporting equipment is used in the Air Traffic Control section of AIMS.

IFF was used during time of war for identifying and locating enemy aircraft. (Now used by Air Traffic Control for locating and identifying aircraft.) The Mark 12 system (another radio set - Receiver-Transmitter is used to identify aircraft in peace time).

The AIMS system uses the following components:

AAU-19/A Servoed Altimeter. (Mechanisms include the normal aneroids connected to the counter-pointer-drum display and contains one part of a servoloop system for the reception of signals from a computer.)

AAU-21/A altimeter-encoder combines a conventional pneumatic (pressure operated) altimeter and an altitude reporting encoder in one self-contained unit.

CPU-46/A or CPU-66/A Computer. (Contains its own aneroid system where signals are developed for transmission to the AAU-19/A altimeter and to the IFF transponder.)

No Response Required

Frame 2

The process involved in the transmission and reception of the altitude signal are as follows:

1. An interrogation pulse is transmitted from the ground unit.

2. This triggers the aircraft transponder causing a pulse reply to be transmitted.

3. The transponder transmission is received by the ground receiver, computer processed and then displayed to the controller on the radar screen, as aircraft identification, assigned altitude, track number and beacon code.

4. The altitude reply is provided in 100' increments by the encoder (computer) signal only when interrogated.

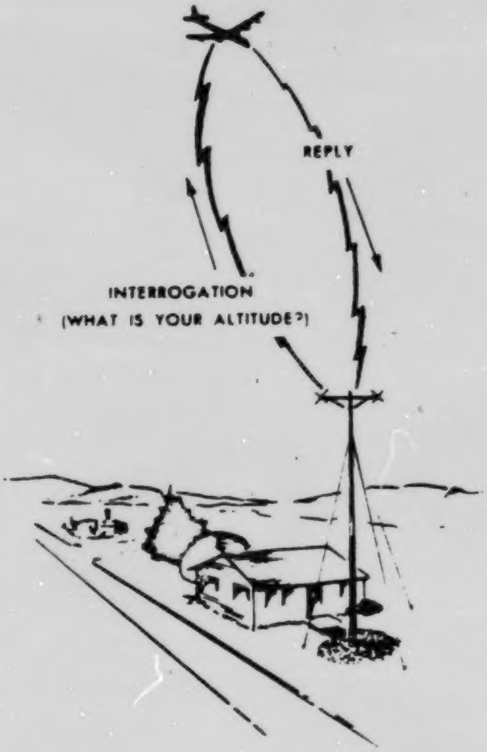

REPLY
INTERROGATION
(WHAT IS YOUR ALTITUDE?)

Figure 1

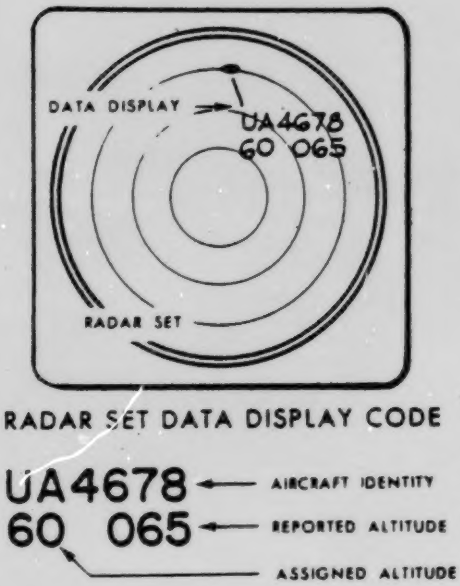

DATA DISPLAY
UA4678
60 065
RADAR SET
RADAR SET DATA DISPLAY CODE
UA4678
AIRCRAFT IDENTITY
60 065
REPORTED ALTITUDE
ASSIGNED ALTITUDE

Figure 2

Circle the letter that identifies the correct answer.

What does the automatic altitude reporting system provide?

a. Continuous altitude in 100' increments to the ground station.

b. Altitude in 100' increments to the standby altimeter.

c. Automatic altitude transmission to the ground station only when interrogated.

Frame 3

The function of the automatic altitude reporting system is to supply outputs of pressure altitude (Hp). These outputs are supplied digitally to the transponder and electrically through synchros to the altimeters. The purpose of the automatic altitude reporting system is to provide altitude information to the altimeters and to transmit altitude to the ground station when interrogated. The AIMS altimetry system accuracy limitations impose the problem of having to eliminate, correct or compensate for almost all errors in the aircraft pitot-static system. Errors produced in measurement and transmission of true pressure altitude can be divided into three groups: (1) static pressure error, (2) errors in pressure transmission and (3) instrument errors. To achieve the greatest accuracy, each type of aircraft must be treated separately as a function of its pressure system and design characteristics. To meet the accuracy requirements of AIMS, three different automatic altitude reporting systems are use: (I) slow, low flying aircraft, (II) medium speed (subsonic) aircraft and (III) high performance (supersonic) aircraft. Reference figure 3 below.

	TYPE I AAU/21A Altimeter-Encoder	TYPE II CPU-66/A Computer *	TYPE III CPU-46/A Computer *
Range	-1000 to +38,000 ft	-1000 to +50,000 ft.	-1000 to +80,000 ft.
Tolerance	± 30 ft. + .2% of altitude	±25 ft. or ±0.25% of altitude	±20 ft. or ± .2% of altitude
Static Pressure Correction	None	0.2 to 0.95 Mach at all altitudes	0.2 to 2.5 Mach at all altitudes
Outputs	Digital Encoder	Digital Encoder Altitude Synchro (2)	Digital Encoder Altitude Synchro (2)

Figure 3.

*CPU-66/A and CPU-46/A computers are used with the AAU-191A servoed altimeter only.

Circle the letter(s) for the correct answer(s).

What are the different automatic altitude reporting systems to meet the accuracy requirements of AIMS?

a. High performance (supersonic) aircraft.

b. Medium speed (subsonic) aircraft.

c. Slow, low flying aircraft.

Answer to Frame 2: c

1249

OPERATION OF COMPONENTS OF AIMS SYSTEMS

Frame 4

The CPU-46/A Altitude Computer is designed for use in high-performance supersonic aircraft. The computer has operational limits of -1,000 to +80,000 feet altitude and 0 to 2.5 mach. It consists of aneroids in two capsules, a computing system, an electronics package, and output devices. The unit operates from the aircraft's pitot-static system and from 115 VAC 400 Hertz power source. The computer provides two outputs of corrected pressure altitude information; a servoed (analog) signal for positioning the remote servoed altimeters (AAU-19/A) and an encoded altitude signal to the aircraft's transponder for altitude reporting. The output of the encoder agrees with the output of the servo to within ±20 feet. Reference figure 4, page 7.

Circle the letter(s) that identify the correct answer(s).

The operational ranges of the CPU-46/A computer are

a. 0 to +80,000' altitude and 0 to 2.0 Mach.

b. 0 to 2.5 Mach and -1,000 to +80,000' altitude.

c. -1,000 to +80,000' altitude and 0 to 1.5 Mach.

d. 0 to 3.0 Mach and -1,000 to +80,000' altitude.

Answers to Frame 3: a. b. c.

1281

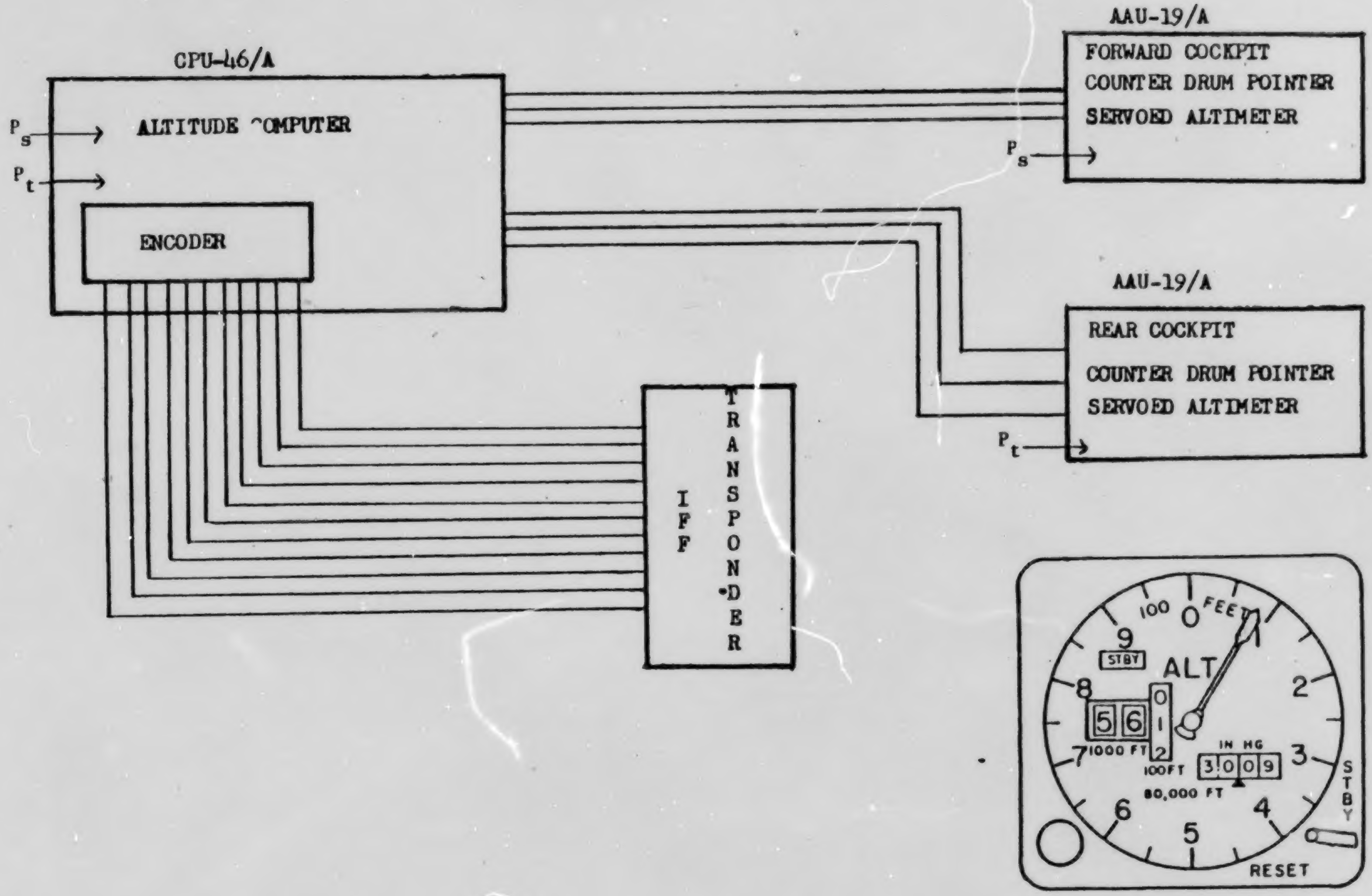

CPU-46/A
ALTITUDE COMPUTER
P_s
P_t
ENCODER
IFF
TRANSPONDER
AAU-19/A
FORWARD COCKPIT
COUNTER DRUM POINTER
SERVOED ALTIMETER
P_s
AAU-19/A
REAR COCKPIT
COUNTER DRUM POINTER
SERVOED ALTIMETER
P_t
100
0
FEET
9
STBY
ALT
8
2
5 6
0 1 2
1000 FT
100FT
IN HG
3 0 0 9
3
7
S T B Y
80,000 FT
6
4
5
RESET

Figure 4

1251
Frame 5

The inputs to the computer are indicated static pressure (PSI), total pressure (Pt) and the known errors of the static pressure system. Mechanical (analog) computations are performed using this input information. Pressure altitude (Hp) is computed and provided as an output signal. Two servoloops in the computer provide the power for the mechanical computations. Data on static system error is obtained from flight test data. Each type of aircraft is flight tested to obtain data on the aircraft's errors. In this way, the same type of computer can be used for many types of aircraft by a simple exchange of an error correction cam inside of the computer.

Circle the letter(s) that identify the correct answer(s).

The input(s) to the CPU-46/A altitude computer are:

a. Static pressure system errors.

b. Indicated static pressure (PSI).

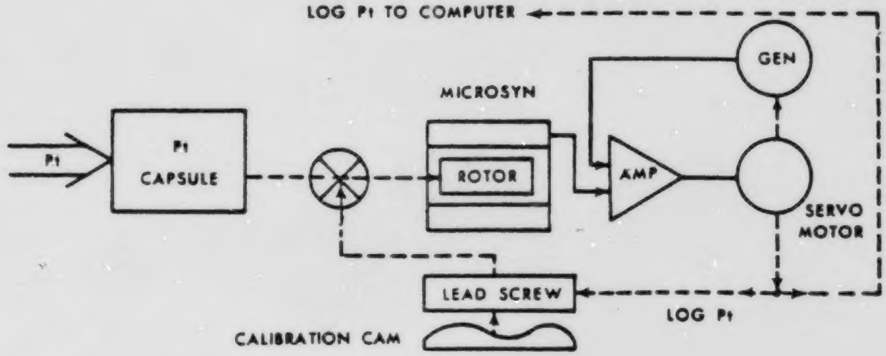
c. Total pressure (Pt).

Answer to Frame 4: b.

1284

Frame 6

The total pressure servoloop consists of two aneroids in a capsule, a servo amplifier, a servo motor and a rate generator. The two symmetrically mounted aneroids operate from the aircraft total pressure (Pt) source. The aneroids rotate a rocking shaft to position the microsyn rotor. An adjustable stack of thin metal plates act as a calibration cam and allow adjustments to be made in the aneroid capsule. The output of the microsyn is fed to the servo amplifier which drives the servo motor and rate generator. The feedback signal of the rate generator is coupled to the servo amplifier to provide damping. The servo motor moves the lead screw to null out the microsyn by realigning the rotor.



Circle the letter(s) of the correct answer(s).

The total pressure sensor of the CPU-46/A computer

a. receives inputs of both pitot and static pressures.

b. consists of two aneroids in a capsule.

c. uses static pressure and measures absolute pressure.

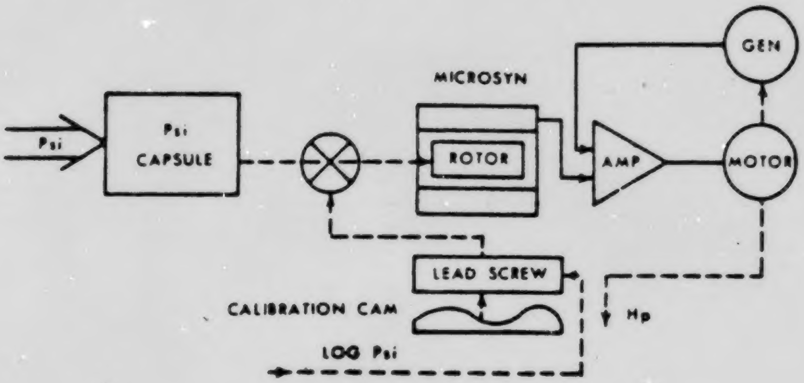
d. receives an input of Pt from the aircraft's pitot-static system.

Answers to Frame 5: a. b. c.

1253

Frame 7

The static pressure servoloop consists of a static pressure capsule, a computing mechanism, a servo amplifier, a servo motor and a rate generator. The static pressure sensor is the same as the total pressure sensor except that the aneroids are constructed for a different pressure range. Indicated static pressure (PSI) is the input to the static sensor. Any variations of PSI rotate the rotor of the microsyn. This causes an error signal to be applied to the servo amplifier. The output of the amplifier causes the servo motor to drive the computing mechanism. The computing mechanism (pg 11) corrects the static pressure and the output then drives the lead screw which repositions the rotor of the microsyn to null the error signal.



Circle the letter(s) of the correct answer(s).

The static pressure servoloop consists of a

a. static pressure sensor.

b. servoamp and microsyn.

c. servomotor and rate generator.

d. all of the above.

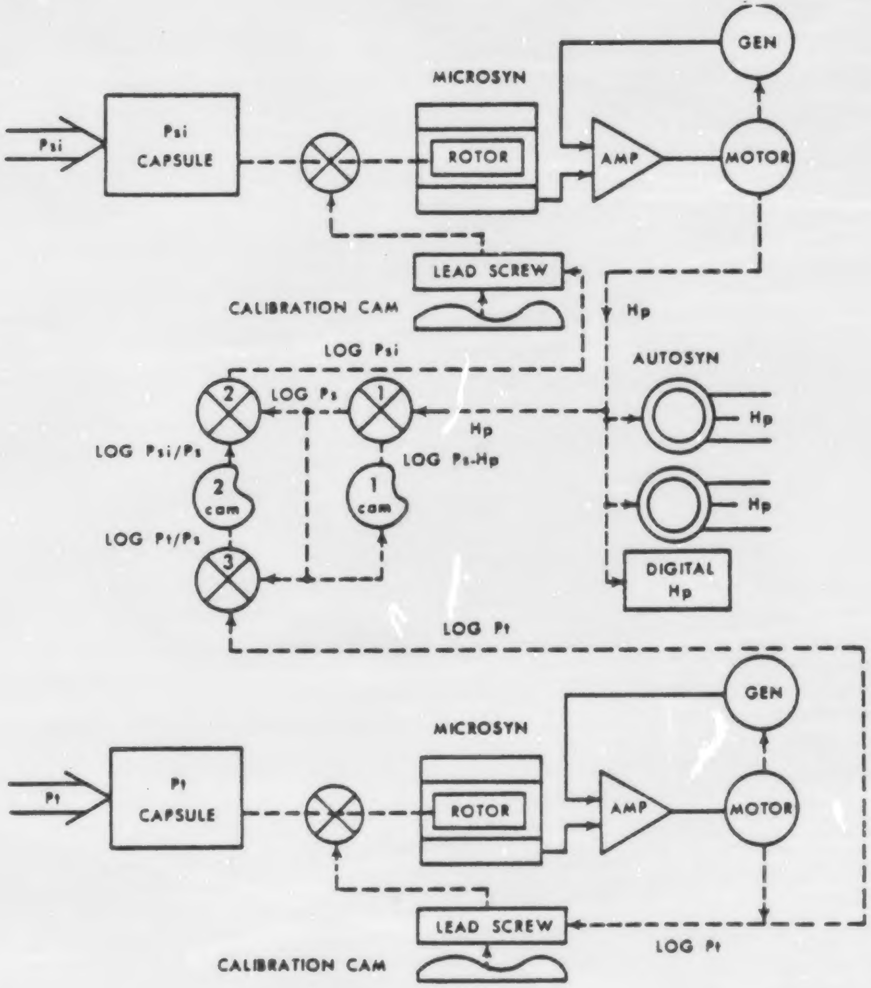
1286

Answers to Frame 6: b. d.

1254

Frame 8

The Pt and PSI servoloops and the mechanical (analog) computing section are combined as shown. Pt and PSI are the inputs. Pressure altitude (Hp), in digital and analog (synchro) form, is the output. Cam number two is an internal input since static pressure corrections are introduced here. The input PSI is corrected to Log PSI in the static sensor. Any input pressure change causes an error signal from the microsyn rotor to be applied to the servo amplifier. The output of the amplifier drives the servomotor which turns the Hp shaft and rate generator. Differential number one and cam number one convert Hp to Log Ps and applies it to differentials number one, two and three. Differential number three combines Log Ps and Log Pt. The output is Log Pt/Ps and is the input to cam number two which in turn transmits its output of Log PSI/Ps to differential number 2. The Log PSI/Ps input and the Log Ps input from differential number one are combined to form output Log PSI. Log PSI closes the servoloop through the calibration cam by aligning the rotor of the microsyn to null the error signal. With this computer, a corrected altitude signal (Hp) is applied to the altimeters and transponder.


GEN
MICROSYN
Psi
Psi CAPSULE
ROTOR
AMP
MOTOR
LEAD SCREW
CALIBRATION CAM
Hp
LOG Psi
AUTOSYN
2
LOG Ps
1
Hp
Hp
LOG Psi/Ps
LOG Ps-Hp
2 cam
1 cam
Hp
LOG Pt/Ps
3
DIGITAL Hp
LOG Pt
GEN
MICROSYN
Pt
Pt CAPSULE
ROTOR
AMP
MOTOR
LEAD SCREW
CALIBRATION CAM
LOG Pt

No Response Required

Answer to Frame 7: d.

1287

1255
Frame 9

A failure detection circuit is provided in the computer. This circuit senses power failures and excessive error voltages in either servoloop. A three-second time delay feature eliminates "nuisance" switching which might be caused by turbulent air or momentary power surges. The failure circuit opens relay contacts to the encoder common lead to prevent an incorrect encoder output. The relay contacts, when opened, also interrupts power to the two servoed altimeters causing them to revert to "standby" mode. When the relay deenergizes, power is provided to the warning lights which warn that AIMS is in the STBY mode.

Circle the letter(s) that identify the correct answer(s).

The purpose of the failure detection circuit in the CPU-46/A computer is to

a. prevent incorrect altitude information being transmitted to the ground station.

b. prevent damage to the CPU-46/A computer.

c. to warn the aircraft crew that the AIMS system is in STBY mode of operation.

d. sense power failure and excessive error voltage.

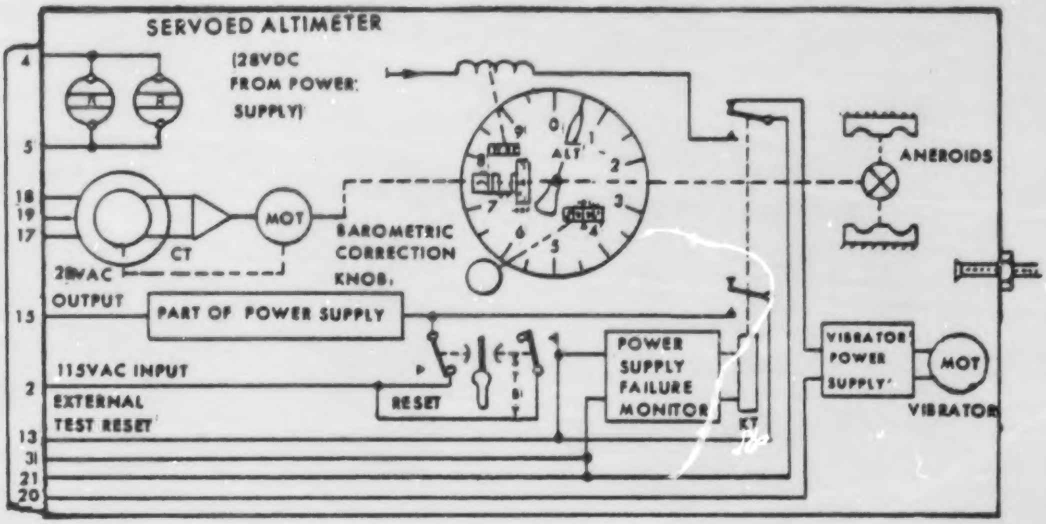
1288

Frame 10

AAU-19/A Servoed Altimeters are instruments which, when coupled with an altitude computer, provide a system designed to meet the requirements for all aircraft and for Air Traffic Control Radar Beacon Systems. These units also provide for automatic standby operation in the event of failure or loss of electrical power.

In the primary mode of operation, the indicator accepts an input synchro signal of true pressure altitude from an altitude computer. A servo mechanism positions the dial display and control transformer to the corresponding altitude of the input signal. If the indicated altitude and synchro inputs are not the same, the servo will drive the pointers to the true position and override the aneroid system. However, if the difference between the servo and aneroids is greater than ± 4500 feet, the altimeter will revert to the standby mode.

In the standby mode of operation, the altimeter operates as a standard barometric altimeter. The pressure input is converted to indicated pressure altitude by means of the two aneroids and a linkage and gear mechanism. The altimeter automatically reverts to the mechanical standby mode by means of an integral failure-sensing system. In the event of primary mode failure, a flag with the letters "STBY" appears on the dial to indicate that the altimeter is operating pneumatically.


SERVOED ALTIMETER
(28VDC FROM POWER SUPPLY)
ANEROIDS
ALT
0
1
2
3
4
5
6
7
8
9
MOT
CT
BAROMETRIC CORRECTION KNOB.
28VAC OUTPUT
PART OF POWER SUPPLY
115VAC INPUT
EXTERNAL TEST RESET
RESET
STBY
POWER SUPPLY FAILURE MONITOR
KT
VIBRATOR POWER SUPPLY
MOT
VIBRATOR
4
5
18
19
17
15
2
13
31
21
20

Circle the letter(s) for the correct answer(s).

The AAU-19/A Altimeter

a. in primary mode, indicator accepts an input synchro signal of true pressure altitude.

b. operates mechanically in the primary mode.

c. a servo mechanism positions the dial display and control transformer to the altitude of the input signal.

d. uses both pitot and static pressures when operating in STBY mode.

Answers to Frame 9: a. c. d.

1257

Frame 11

The altimeter has a built in amplifier which contains a failure sensing circuit. In the event of a power or servo system failure, the sensing circuit will cause the altimeter to automatically revert to the standby mode. At that time the STBY flag appears on the dial to indicate that the altimeter is in the standby mode of operation due to some sort of failure. If the failure proves to be a momentary one, the altimeter can be reset by placing the Standby-Reset lever to Reset until the STBY flag disappears from view. If the failure remains, the altimeter will not reset. However, the altimeter will operate normally in the standby position with the flag in view. The preferred mode of operation for this altimeter is electrical (servoed) unless failures prohibit this. The pneumatic (standby) mode may be selected at any time by holding the Standby-Reset lever in the Standby position until the flag comes into view. Note: The positioning of the Standby-Reset switch solely determines the mode of operation of the altimeter and in NO way controls the operation of the computer.

Circle the letter(s) for the correct answer(s).

When will the AAU-19/A altimeter automatically revert to the Standby mode of operation?

a. Power failure.

b. Servo failure.

c. Clogged pitot tube.

d. Broken static line.

1290

Answers to Frame 10: a. c.

When the altimeter is in the standby mode, a 28 VDC vibrator is energized. Moving the lever to Reset until the standby flag goes out of view, will deenergize the vibrator. The purpose of the vibrator is to reduce the effect of friction. Less friction enables the instrument to provide a smoother display when altitude changes occur. If the vibrator fails, the altimeter will continue to provide a display. The only difference will be less smooth pointer movement with changes of altitude.

Circle the letter(s) that identify the correct answer(s).

When is the vibrator used to reduce the affects of friction?

a. In the reset mode.

b. In the standby mode.

c. In the reset and standby modes.

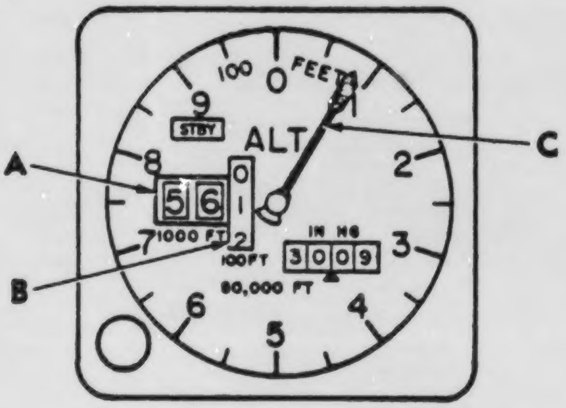
d. When 28 VDC power to the altimeter fails.

Answers to Frame 11: a. b.

1259

Frame 13

The AAU-19/A altimeter has a counter (A), drum (B) and pointer (C) display as shown below. The 1,000 foot counter and the 100 foot drum provides a direct digital reading of altitude. These readings are in increments of 100 feet and range from -1,000 to +80,000 feet. The pointer (C) repeats the 100 foot readings of the drum (B) and gives a more accurate reading than the drum. Two methods are utilized in reading the altimeter. One is to read the counter and drum windows without reference to the pointer. The other is to read the counter and pointer and skip the drum.



Circle the letters of the correct answers.

1. What is the altimeter indicating, using the drum method of reading the altimeter?

   a. 5,610 feet.

   b. 3,009 feet.

   c. 56,000 feet.

   d. 56,100 feet.

2. What is the altimeter indicating, using the counter/pointer method of reading the altimeter?

   a. 56,040 feet.

   b. 56,085 feet.

   c. 56,140 feet.

   d. 56,185 feet.

1292

Answer to Frame 12: b.

The altimeter is set by using the manually operated barometric set knob. The barometric scale appears on counters and is read in inches of Hg (mercury). The barometric scale has a calibrated range of 28.10 to 31.00 inches of Hg. The altimeter setting should be made in both pneumatic (standby) and the servoed (reset) mode of operation. The altimeter setting is accomplished as follows:

Position the Standby-Reset switch to standby. Adjust the barometric set knob so that the altimeter pointer indicates field elevation. Extend and rotate the barometric set knob until the barometric counter agrees with the local barometric pressure. The knob is then returned to the center position. This completes the pneumatic (standby) adjustment.

The servoed (reset adjustment is accomplished by first positioning the Standby-Reset switch to Reset). With the barometric set knob in the center position, rotate the knob so that the barometric counter indicates local barometric pressure. Depress the barometric set knob and adjust the altimeter pointer to field elevation. Return the barometric knob to the center position and lock into place.

Verify the altimeter settings by moving the altimeter Standby-Reset switch first to standby then to reset. The pointer shall continue to indicate field elevation ±5 feet.

Circle the letter(s) that identifies the correct answers.

In what mode(s) should the AAU-19/A altimeter setting be accomplished?

a. Standby.

b. Reset.

c. Interrogation.

d. Barometric.

Answers to Frame 13: 1. d. 2. b.

Frame 15

You learned in the preceding pages that the altimeter has two inputs: a pneumatic input of indicated static pressure (PSI) from the aircraft's pitot-static system and a servo (electrical) input from the CPU-46/A or CPU-66/A altitude computers or an air data computer. The AAU-19/A altimeter can be used with any one of the above computers. The primary mode of operation for AIMS is the servo (electrical) mode. The synchro signal will override the pneumatic signal to the altimeter when the altimeter is in the reset mode.

Match the items in Column "A" to their functions in Column "B" by placing the correct letter of the function in the correct space in Column "A."

Column A	Column B
_____ 1. Baro set knob.	a. No automatic altitude reporting available in the event of servo system failure.
_____ 2. Standby mode.	b. Used to perform an altimeter setting.
_____ 3. Aneroids.	c. Indicates sea level pressure in inches of Hg.
_____ 4. Barometric scale.	d. Precision pressure mechanism.

Answers to Frame 14: a. b.

The CPU-66/A Altitude Computer is designed for use from -1,000 to +50,000 feet altitude at speed from 0 to 0.95 mach. The altitude computer consists of pressure sensing means, a computing mechanism, an error signal generator, a servoloop and output devices. The computer provides corrected pressure altitude (Hp) from the inputs of indicated static pressure (PSI) and total pressure (Pt). The static pressure correction cam is readily replaceable in the event that a change is necessary or if the computer is to be used in a different type aircraft. Reference figure 5 on page 21.

The CPU-66/A Altitude Computer provides two outputs of corrected altitude information; a servoed (analog) signal for positioning the remote servoed altimeters (AAU-19/A) and an encoded altitude signal to the aircraft's transponder for altitude reporting.

Although the CPU-66/A Altitude Computer uses the same inputs and provides the same type outputs as the CPU-46/A, it does not process the input signals to provide the outputs of corrected proessure altitude in the same manner.

NO RESPONSE REQUIRED

Answers to Frame 15: 1. b, 2. a, 3. d, 4. c.

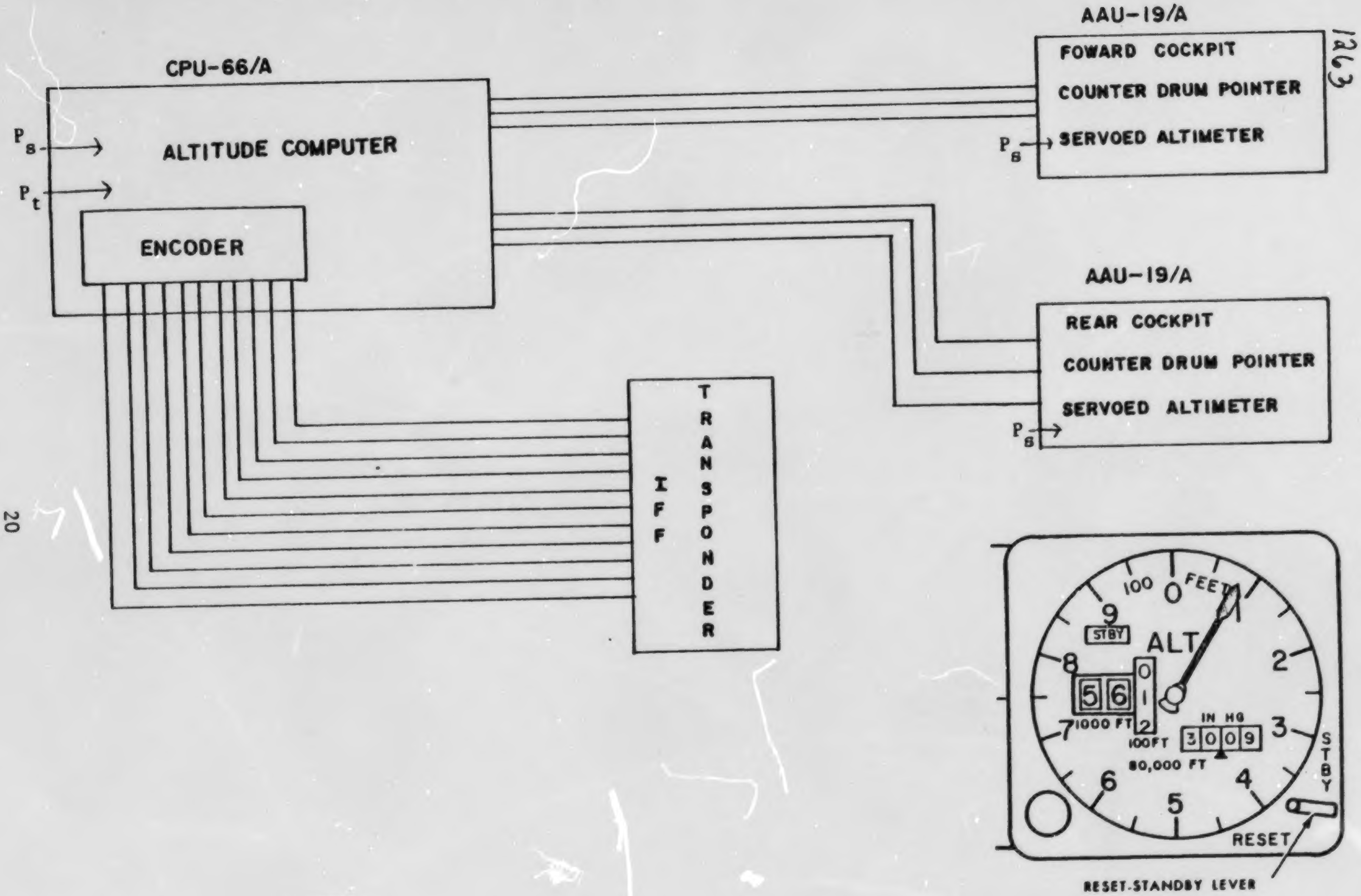
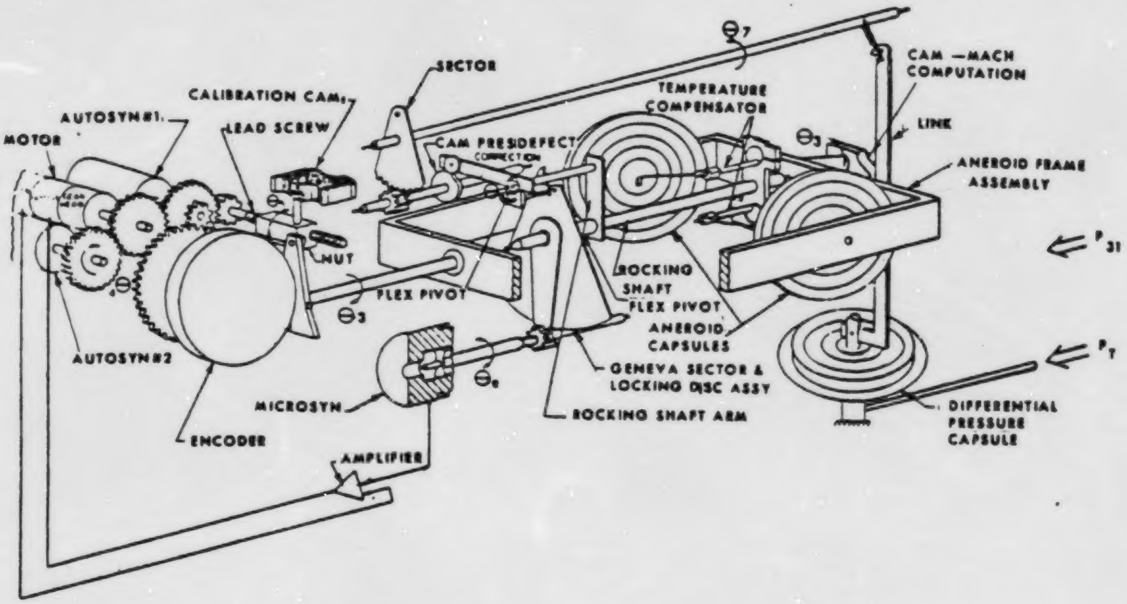

CPU-66/A
ALTITUDE COMPUTER
P_s
P_t
ENCODER
AAU-19/A
FOWARD COCKPIT
COUNTER DRUM POINTER
SERVOED ALTIMETER
P_s
AAU-19/A
REAR COCKPIT
COUNTER DRUM POINTER
SERVOED ALTIMETER
P_s
IFF
TRANSPONDER
100
0
FEET
9
STBY
ALT
8
2
5 6
0 1 2
7
1000 FT
100FT
IN HG
3 0 0 9
3
80,000 FT
6
4
5
STBY
RESET
RESET-STANDBY LEVER

Figure 5

Frame 17 1264

Two types of pressure sensing devices are used in the CPU-66/A computer. The uncorrected altitude is sensed by a pair of aneroids. As the external pressure decreases, the size of the aneroids increases. The size of the aneroids decreases as the external pressure increases. The second type of pressure sensor is an airspeed diaphragm capsule. The airspeed diaphragm capsule, responds to the difference between total pressure (Pt) and static pressure (Ps). Aircraft total pressure is transmitted into the airspeed diaphragm capsule through a tube leading from the pitot pressure port. Since the airspeed diaphragm capsule has static pressure acting on the external surface, the capsule height increases as the differential pressure (pitot pressure minus static pressure) increases.


Θ_7
SECTOR
CAM —MACH COMPUTATION
CALIBRATION CAM
TEMPERATURE COMPENSATOR
AUTOSYN#1
LEAD SCREW
LINE
MOTOR
CAM PRESIDEFECT CORRECTION
Θ_3
ANEROID FRAME ASSEMBLY
NUT
P_{31}
ROCKING SHAFT
FLEX PIVOT
FLEX PIVOT
Θ_3
ANEROID CAPSULES
AUTOSYN#2
P_T
GENEVA SECTOR & LOCKING DISC ASSY
Θ_e
MICROSYN
ROCKING SHAFT ARM
DIFFERENTIAL PRESSURE CAPSULE
ENCODER
AMPLIFIER

Circle the letter(s) of the correct answer(s).

What are the sensing devices used in the CPU-66/A altitude computer?

a. Aneroids and a diaphragm.

b. Aneroid and bellows.

c. Diaphragm and bellows.

d. Bellows and bourdon tube.

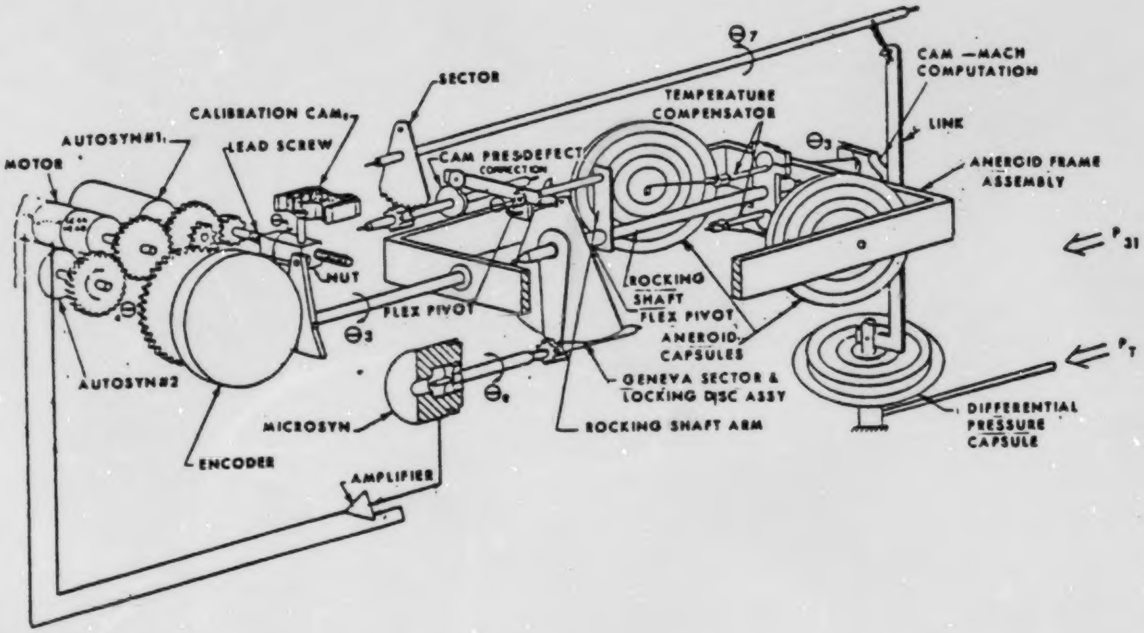
1298

1265

Frame 18

Linkage attached to the aneroids provide displacement which rotates the main rocking shaft as a function of uncorrected altitude. A pinion on the microsyn rotor shaft is driven by the arm on the rocking shaft through the Geneva sector and disk assembly. The error signal generated by the microsyn is fed to the servo amplifier. The amplifier output is supplied to the servomotor which drives the rate generator and the servo gear train. The encoder and synchro output devices are driven until the error signal is cancelled and the servo is back to the null condition. The rate generator output is coupled back to the amplifier to provide negative feedback for damping and stability.

No Response Required


Θ_7
CAM —MACH COMPUTATION
SECTOR
TEMPERATURE COMPENSATOR
CALIBRATION CAM
LINK
AUTOSYN#1
LEAD SCREW
Θ_3
MOTOR
CAM PRES-DEFECT CORRECTION
ANEROID FRAME ASSEMBLY
P_{31}
NUT
ROCKING SHAFT
FLEX PIVOT
FLEX PIVOT
Θ_3
ANEROID CAPSULES
P_T
AUTOSYN#2
GENEVA SECTOR & LOCKING DISC ASSY
Θ_8
DIFFERENTIAL PRESSURE CAPSULE
MICROSYN
ROCKING SHAFT ARM
ENCODER
AMPLIFIER

1299

Answer to Frame 17: a.

A failure monitor circuit is provided in the computer. In the event of power losses or excessive error voltages, the failure monitor relay deenergizes. This in turn opens the relay contacts to the encoder common lead to prevent an incorrect encoder output. Power to the servoed altimeter is also interrupted causing them to revert to the "standby" mode. Power is provided to the warning lights to indicate the AIMS system is in the STBY mode. A three second time delay is provided to prevent "nuisance" switching which might be caused by turbulent air or momentary power surges.

Circle the letter(s) that identifies the correct answer(s).

What is the period of time delay in the failure monitor circuit of the CPU-66/A altitude computer?

a. 1 second.

b. 3 seconds.

c. 1 minute.

d. 3 minutes.

Frame 20

The AAU-21/A altimeter-encoder combines a conventional pneumatic (pressure operated) altimeter, counter/drum pointer display, and an altitude-reporting encoder in one self-contained unit. The 1,000 foot counter and the 100 foot drum provide a direct digital readout of altitude in 100 foot increments from -1,000 to +38,000 feet. The pointer repeats the indications of the 100 foot drum.

The self-contained servo driven encoder provides altitude in 100 foot increments for automatic transmission when the AIMS transponder is interrogated by the ground control station. The components which position the encoder consist of a servo amplifier, a servo motor and a synchrotel. With changes in pressure due to changes in altitude, the altimeter mechanism positions the dial display and also the rotor of the synchrotel. As the rotor turns, an error voltage is developed and amplified to drive the servo motor. The servo motor rotates the synchrotel case to maintain electrical zero, and at the same time positions the encoder inside the altimeter.

In case of power loss to the encoder servo system, a CODE OFF flag will appear automatically in a window in the upper left portion of the altimeter dial, indicating that altitude information is no longer available to be transmitted to the ground. In this condition the instrument continues to function as a normal barometric altimeter. When power is applied, the encoder will become operable as the CODE OFF flag retracts from view. Reference figure 6 on page 25.

Circle the letter(s) that identifies the correct answer(s).

Under which of the following conditions can the AAU-21/A altimeter encoder be used?

a. Low speed, low altitude.

b. Medium speed, medium altitude.

c. High speed, high altitude.

Answer to Frame 19: b.

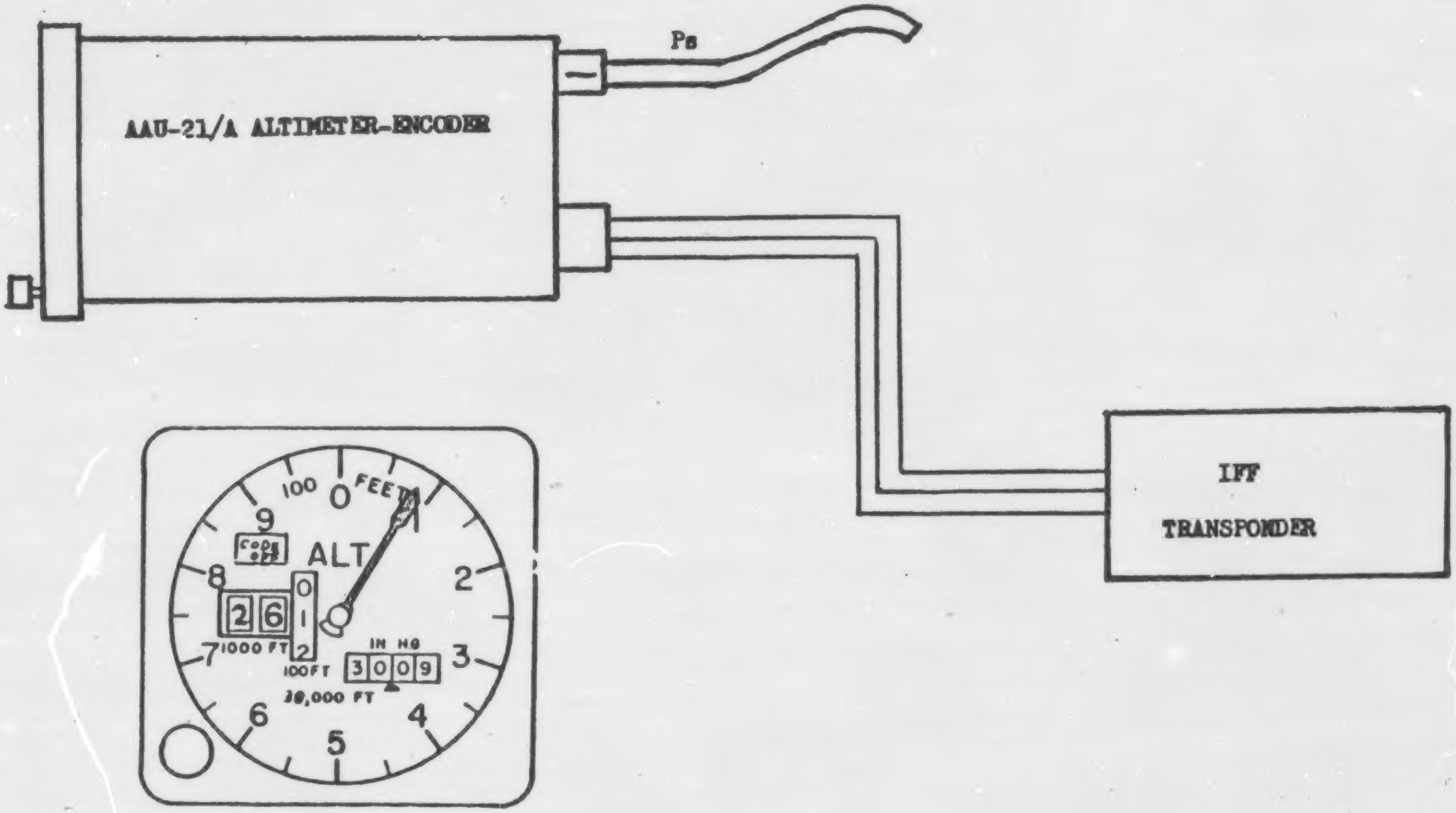

Ps
AAU-21/A ALTIMETER-ENCODER
IFF
TRANSPONDER
100
0
FEET
1
2
3
4
5
6
7
8
9
ALT
CODE OFF
2 6
0 1 2
1000 FT
100 FT
IN HG
3 0 0 9
30,000 FT

Figure 6.

1269

Frame 21

The IFF (identification friend or foe) transponder set provides automatic identification of the aircraft in which it is installed, when interrogated by the ground station. In operation, the identification system receives coded interrogation signals, evaluates these signals, then transmits coded response signals to the source of the challenge. Proper reply indicates the interrogated aircraft is friendly. The IFF system interfaces with the AIMS system for altitude reporting. The modes provided for interrogation or automatic response to interrogation signals are: mode 1 for security identification mode 2 for personal identification, mode 3/A for traffic identification and mode C. Mode C is the mode used in conjunction with the AIMS system. The IFF transponder receives coded barometric altitude information from the altitude encoder. The transponder control panel has a mode C selector switch with two positions: ON which enables response to mode C interrogation; Out which disables mode C response.

Circle the letter(s) for the correct answer(s).

The AIMS system uses which IFF transponder mode(s)?

a. Mode 1.

b. Mode 2.

c. Mode 3/A.

d. Mode C.

1304

Answers to Frame 20: a.

1270

TROUBLESHOOTING

Frame 22

We will not discuss troubleshooting of the AIMS system. To accomplish troubleshooting, you will be using the Altitude Encoder Logic Chart, which is extracted from the AIMS system technical order. It contains encoder logic output information for various altitudes. You will also use the AIMS system diagram in order to analyze various malfunctions in the AIMS system.

Troubleshooting of the AIMS system centers around the altitude computer and the type of problems encountered. One type of problem is when the cockpit altimeters are in error between STBY (pneumatic) and reset (electrical) modes or that the system won't stay in the reset (electrical) mode. A problem of this type could be caused by power, wiring between the computer-encoder and the altimeters, a malfunctioning computer-encoder, or pitot-static pressure problems.

Another type of problem is a difference between the cockpit altimeters and the altitude received by the ground station. This type of problem could be caused by a malfunctioning computer-encoder output or faulty wiring between the computer-encoder and the IFF transponder.

No Response Required

Answer to Frame 21: d.

Frame 23

Typical problems are:

1. An open wire between the computer-encoder and the altimeter causing erratic altimeter operation and the altimeter to revert to STBY mode. An open wire between the computer-encoder and the IFF transponder causing erroneous altitude outputs to the ground station.

2. Shorts, either to another wire or to ground, between the computer-encoder and the altimeter causing erratic altimeter readings and the altimeter will revert to STBY mode. If the short is between the computer-encoder and the IFF transponder, it will cause erroneous altitude outputs to the ground station.

3. Pitot-static problems will cause the same type of problems as with conventional systems except that two units will be affected, the altimeters and the altitude computer-encoder.

After you have these typical problem areas firmly in mind, continue to the next frame.

No Response Required

When the ground station reports a different altitude than the aircraft, the pilot will normally switch the altimeters to standby to check them. In the problems we give you, you should assume the pilot has checked the altimeters and found them to be accurate.

When the aircraft changes altitude, the ground station will not be able to keep up with the changes. Therefore, they won/t check the altitude until the aircraft has reached cruising altitude.

You may notice that the problems we give you would cause discrepancies at other altitudes as well as the ones mentioned. However, since they only check the output at cruising altitude, the pilot and ground station will not be aware of the problem at the other altitudes.

Check (√) the correct statement(s) below:

_____1. The pilot can check his altimeter reading by manually switching his altimeters to standby.

_____2. The ground station will check the output it receives during the time the aircraft is ascending.

_____3. Normally the ground station will check the output it receives at cruising altitude only.

Frame 25

Before we give you some problems, we will discuss how to use the altitude encoder output logic chart. This chart shows you what logic must be on for the ground station to read the different altitudes. For example to transmit a reading of 6900 feet logic A2, A4, C2 and C4 should be on. Suppose the ground station reports that it is receiving an output of 6800 feet instead of the 6900 feet output it should be receiving. Look at your chart again, to read 6800 feet logic A2, A4 and C4 should be on.

You now have enough information to locate your problem. Compare logic output of 6800 feet and 6900 feet, the only difference is that C2 is on at 6900 feet and off at 6800 feet. Therefore, your problem is that the ground station isn't receiving an output from C2. This could be caused by wire C2 being open or shorted to ground. By using your wiring diagram you can see which pin you should check.

Check (✓) the correct response(s) below:

1. An aircraft is at 6400 feet but the ground station is receiving an output indicating that the aircraft is at 6500 feet. This could be caused by

_____a. A4 wire being open.

_____b. C1 wire being open.

_____c. C1 wire being shorted to ground.

_____d. C1 wire being shorted to C2.

_____e. C2 wire being open.

Answers to Frame 24: __✓__1. _____2. __✓__3.

Let's look at one other example using your logic chart. The ground station is receiving an output of 7300 feet and the aircraft is at 7200 feet. First compare the output for each altitude. The output for 7300 feet is A2, A4, B4 and C1; and the output for 7200 feet is A2, A4 and C1. Output B4 is the only one that the two altitudes do not have in common. Since the ground station is receiving an output of 7300 feet instead of 7200 feet, it is receiving an output from B4. This could only be caused by wire B4 being shorted to wire C1. Now you are ready to go to your wiring diagram.

Check (✓) the correct response(s) below:

1. An aircraft is at a cruising altitude of 5500 feet. The ground station indicates that its reading shows it at 5400 feet. This could be caused by

_____a. C1 wire being open.

_____b. C1 wire being shorted to B4.

_____c. C1 wire being shorted to C2.

_____d. C1 wire being shorted to ground.

Answers to Frame 25: _____a. __✓__b. __✓__c. _____d.

Frame 27

Following are some examples of wiring problems. Remember that the pilot may not see all of the problems that may occur to the AIMS system and will usually notice problems only at cruising altitudes. The problems are presented in a manner in which you would see them written in the AFTO Form 781A.

In the samples below, trace the problems using the Logic Chart and the schematic.

1. The pilot reported that the cockpit altimeters were reading 9,000 feet when the ground station reported the altitude at 8,900 feet. By looking at the altitude encoder output logic chart, you find that the only difference in these altitudes is logic C-4. The only possible cause of this problem is either a malfunctioning computer-encoder or a shorted wire between C4 and A2, A4, B1, B2 or C2. Now look at the schematic of the AIMS system, check the IFF transponder shift register and find which wire carries output C4. You'll find that the wire from pin 15 of J1(66P408C) to pin 15 J1(71P311A) must be shorted to A1 wire carrying output A2, A4, B1, B2 or C2.

2. Open or short to ground: The aircraft altimeters indicated 8,000 feet and the ground station reported 7,500 feet. By looking at these two altitudes on encoder output logic chart we find that the only difference is logic B-2. We now have three possible problems, a malfunctioning computer-encoder, an open wire or shorted wire to ground at pin 11 of J1(66P408C) of the IFF transponder or an open wire or shorted wire to ground at pin 11 of J1(71P311A) of the altitude computer. Assuming that the altitude computer-encoder has bench checked good, then this problem would be faulty wiring. Only one answer will be given that is correct, either open or shorted wires will kill logic B-2 to the transponder.

Continue with the following problems:

1. The ground station reported the aircraft at 6,000 feet while the aircraft altimeters indicated 6,100 feet. The trouble could be

   a. open between pin 13 of J1(71P311A) and pin 13 of J1(66P408C).

   b. open between pin 15 of J1(71P311A) and pin 15 of J1(66P408C).

   c. short between pins 12 and 13 of J1(66P408C).

   d. short between pins 13 and 14 of J1(71P311A).

2. Both altimeters in the STBY mode indicated cabin pressure altitude. The trouble could be

   a. broken pitot line.

   b. broken static line.

   c. clogged static line.

   d. clogged pitot tube.

3. The pilot and co-pilot reported that both the front cockpit and rear cockpit altimeters failed to show a change in altitude in both reset and STBY modes. The trouble could be

    a. clogged static port.

    b. clogged pitot tube.

    c. defective computer.

    d. defective altimeter.

4. During flight, the ground station reported the aircraft at 8,700 feet while the aircraft altimeters read 8,800 feet. The trouble could be

    a. open between pin 7 of J2(71P311B) and pin 18 of 66P/J316.

    b. open between pin 11 of J1(71P311A) and pin 11 of J1(66P408C).

    c. open between pin 10 of J1(71P311A) and pin 10 of J1(66P408C).

    d. open between pin 9 of J1(71P311A) and pin 9 of J1(66P408C).

5. During flight, the aircraft altimeters indicated 3,300 feet while the ground station reported 4,200 feet. The trouble could be

    a. open between pin 10 of J1(71P311A) and pin 10 of J1(66P408C).

    b. short between pins 12 and 13 of J1(71P311A).

    c. open between pin 11 of J1(71P311A) and pin 11 of J1(66P408C).

    d. short between pins 11 and 12 of J1(71P311A).

6. During flight, the pilot reported that the F/C/P altimeter fluctuated in the Reset mode before switching to the STBY mode. The trouble could be

    a. open between pin 5 of J2(71P311B) and pin 15 of 66P/J316.

    b. open between pin 12 of J1(71P311A) and pin 12 of J1(66P408C).

    c. open between pin 10 of J2(71P311B) and pin 18 of 66P/J317.

    d. open between pin 9 of J2(71P311B) and pin 17 of 66P/J316.

7. The co-pilot reported that his altimeter stopped moving in the Reset mode before automatically switching into the STBY mode. The trouble could be

   a. open between pin 1 of J2(71P311B) and pin 15 of 66P/J317.

   b. open between pin 5 of J2(71P311B) and pin 15 of 66P/J316.

   c. open between pin 14 of J1(71P311A) and pin 14 of J1(66P408C).

   d. open between pin 12 of J2(71P311A) and pin 17 of 66P/J317.

8. The pilot reported that the front cockpit altimeter failed to function in the STBY mode. The trouble could be

   a. defective altimeter.

   b. defective computer.

   c. clogged pitot line.

   d. defective transponder.

Answers to Frame 26: ____a. __✓__b. __✓__c. ____d. ____e.

Answers to Troubleshooting Problems: 1. a. 2. b. 3. a. 4. c.
5. d. 6. d. 7. a. 8. a.

Altitude Encoder Logic Output Chart

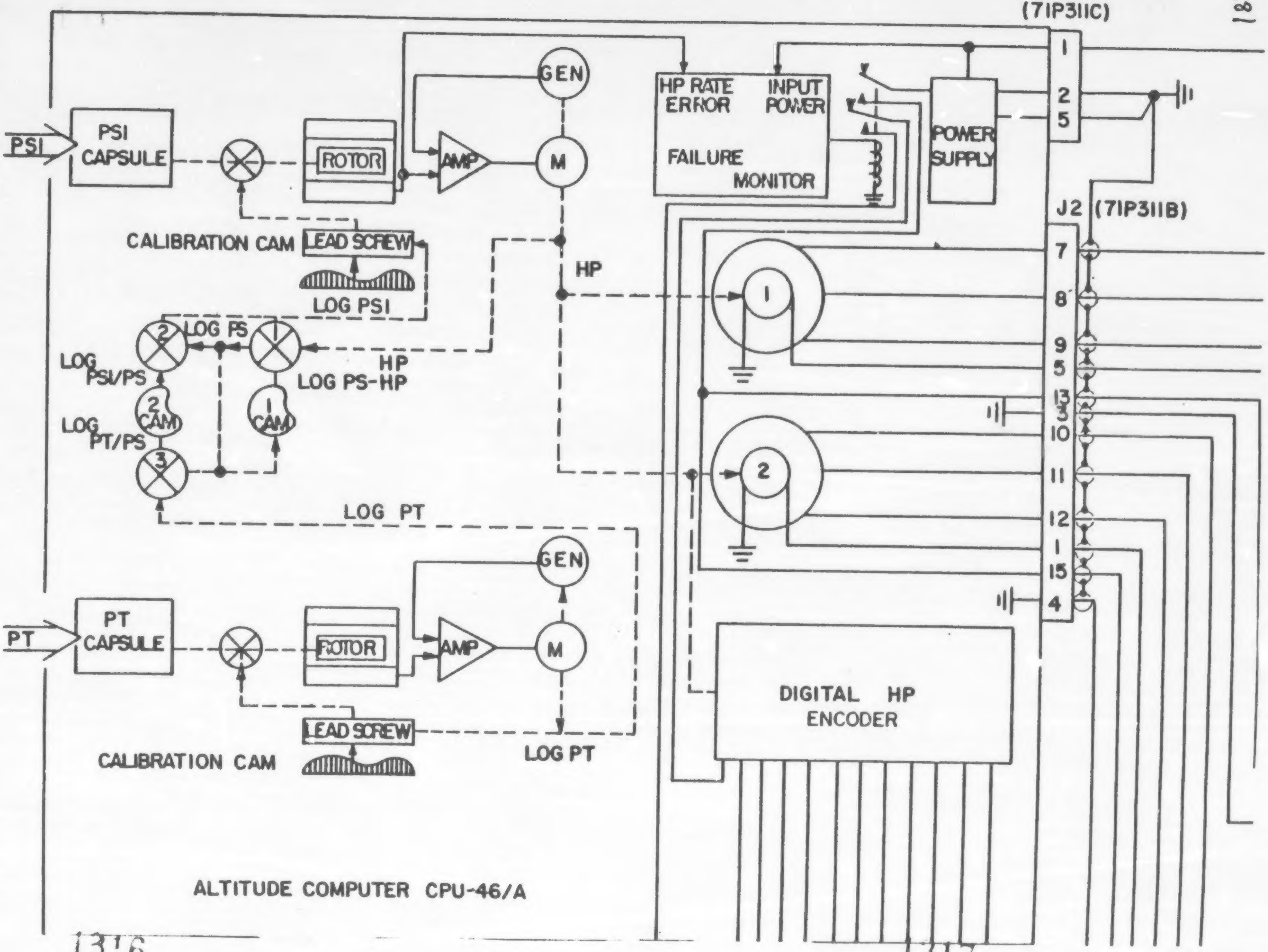
Altitude (±50 Feet)	Encoder Outputs (X Denotes Output in Use)										
	D2	D4	A1	A2	A4	B1	B2	B4	C1	C2	C4
0							X	X		X	
100							X	X	X	X	
200							X	X	X		
300							X		X		
400							X		X	X	
500							X			X	
600							X			X	X
700							X				X
800						X	X				X
900						X	X			X	X
1000						X	X			X	
1100						X	X		X	X	
1200						X	X		X		
1300						X	X	X	X		
1400						X	X	X	X	X	
1500						X	X	X		X	
1600						X	X	X		X	X
1700						X	X	X			X
1800						X		X			
1900						X		X		X	X
2000						X		X		X	
2100						X		X	X	X	
2200						X		X	X		
2300						X			X		
2400						X			X	X	
2500						X				X	
2600						X				X	X
2700						X					X
2800					X	X					X
2900					X	X				X	X
3000					X	X				X	
3100					X	X			X	X	
3200					X	X			X		
3300					X	X		X	X		

Altitude Encoder Logic Output Chart

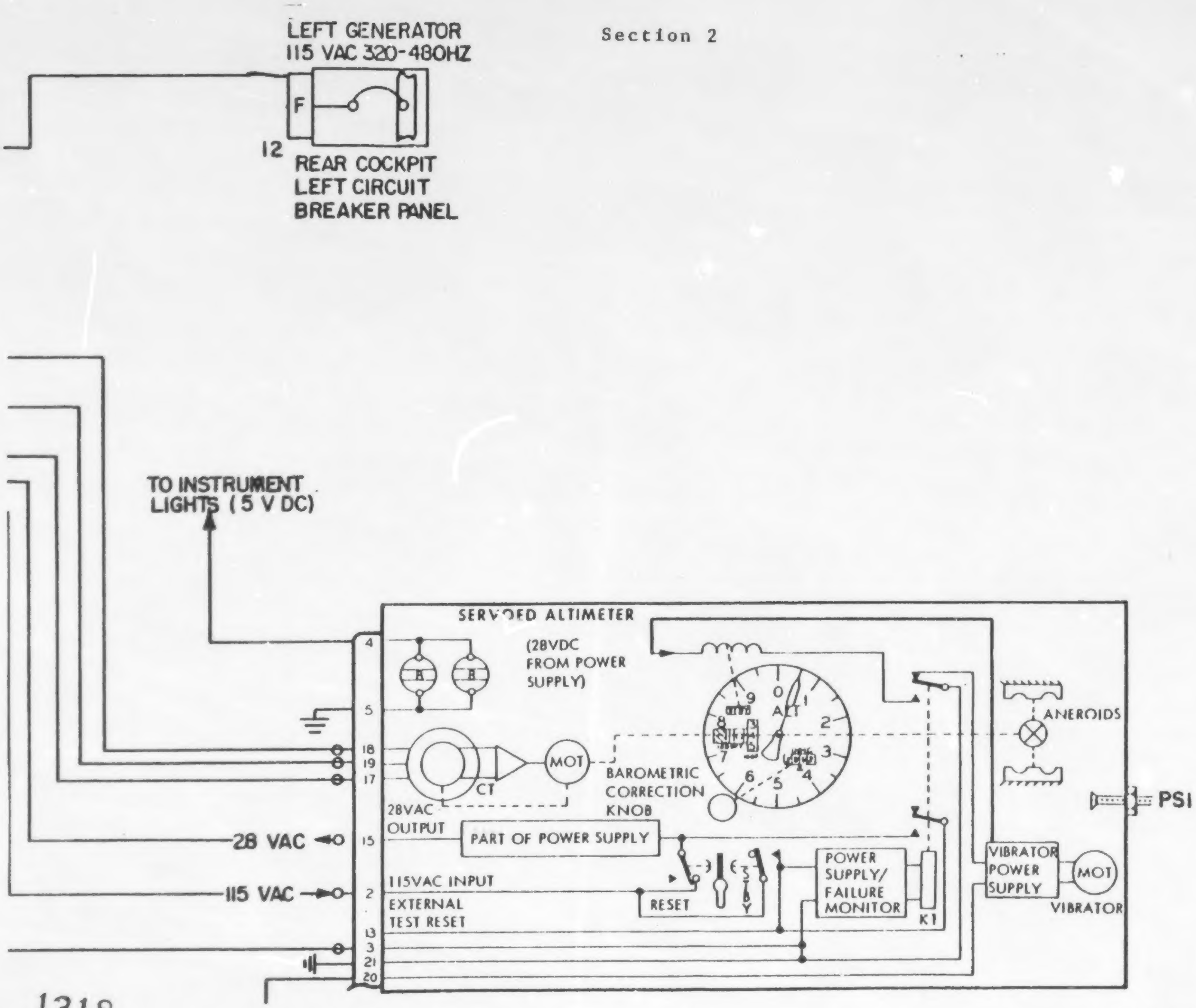
Altitude (±50 Feet)	Encoder Outputs (X Denotes Output in Use)										
	D2	D4	A1	A2	A4	B1	B2	B4	C1	C2	C4
3400					X	X		X	X	X	
3500					X	X		X		X	
3600					X	X		X		X	X
3700					X	X		X			X
3800					X	X	X	X			X
3900					X	X	X	X		X	X
4000					X	X	X	X		X	
4100					X	X	X	X	X	X	
4200					X	X	X	X	X		
4300					X	X	X		X		
4400					X	X	X		X	X	
4500					X	X	X			X	
4600					X	X	X			X	X
4700					X	X	X				X
4800					X		X				X
4900					X		X			X	X
5000					X		X			X	
5100					X		X		X	X	
5200					X		X		X		
5300					X		X	X	X		
5400					X		X	X	X	X	
5500					X		X	X		X	
5600					X		X	X		X	X
5700					X		X	X			X
5800					X			X			X
5900					X			X		X	X
6000					X			X		X	
6100					X			X	X	X	
6200					X			X	X		
6300					X				X		
6400					X				X	X	
6500					X					X	
6600					X					X	X
6700					X						X

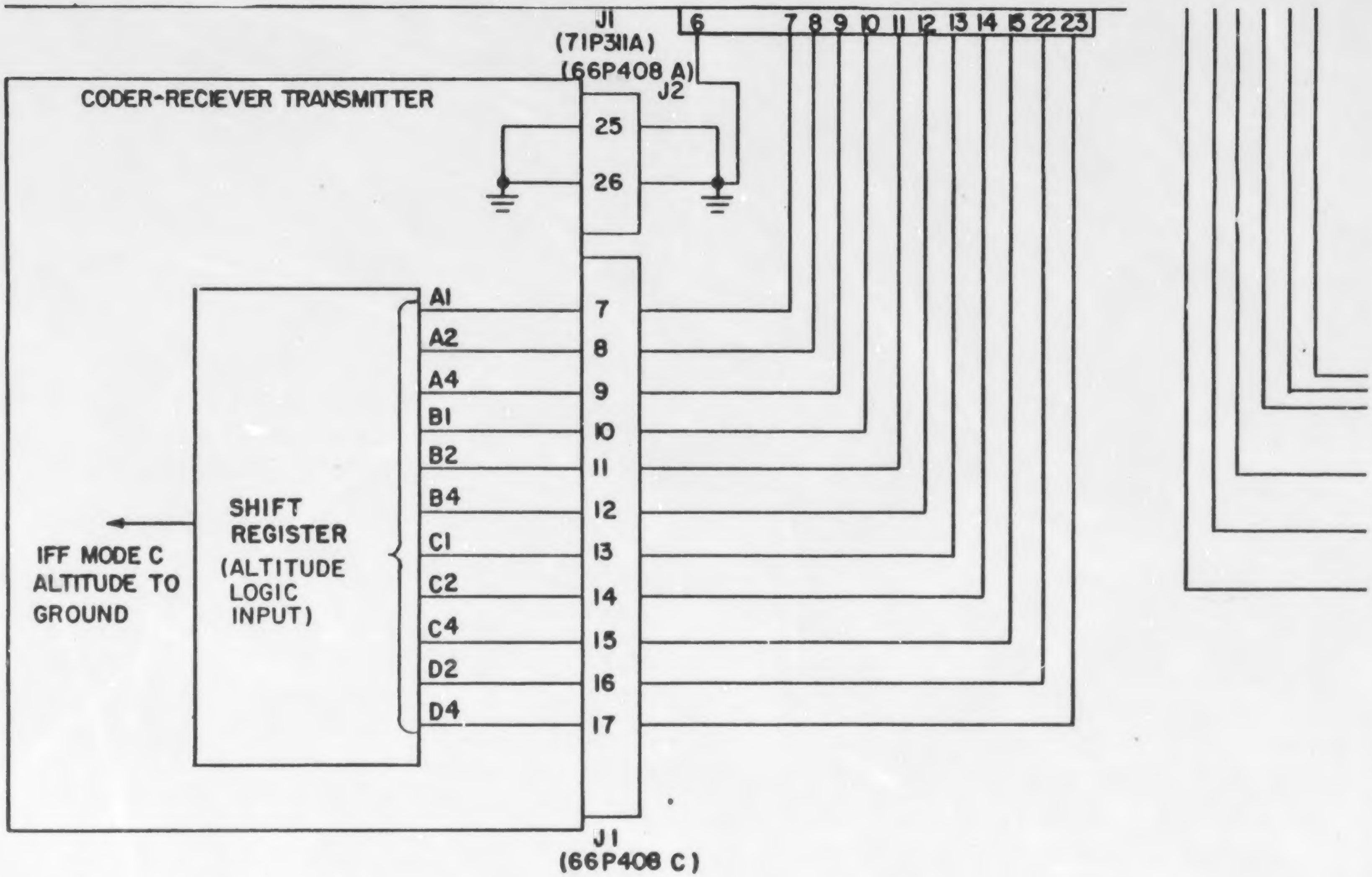
Altitude Encoder Logic Output Chart

Altitude (±50 Feet)	Encoder Outputs (X Denotes Output in Use)										
	D2	D4	A1	A2	A4	B1	B2	B4	C1	C2	C4
6800				X	X						X
6900				X	X					X	X
7000				X	X					X	
7100				X	X				X	X	
7200				X	X				X		
7300				X	X			X	X		
7400				X	X			X	X	X	
7500				X	X			X		X	
7600				X	X			X		X	X
7700				X	X			X			X
7800				X	X		X	X			X
7900				X	X		X	X		X	X
8000				X	X		X	X		X	
8100				X	X		X	X	X	X	
8200				X	X		X	X	X		
8300				X	X		X		X		
8400				X	X		X		X	X	
8500				X	X		X			X	
8600				X	X		X			X	X
8700				X	X		X				X
8800				X	X	X	X				X
8900				X	X	X	X			X	X
9000				X	X	X	X			X	
9100				X	X	X	X		X	X	
9200				X	X	X	X		X		
9300				X	X	X	X	X	X		
9400				X	X	X	X	X	X	X	
9500				X	X	X	X	X		X	
9600				X	X	X	X	X		X	X
9700				X	X	X	X	X			X
9800				X	X	X		X			X
9900				X	X	X	X			X	X
10000				X	X	X		X		X	

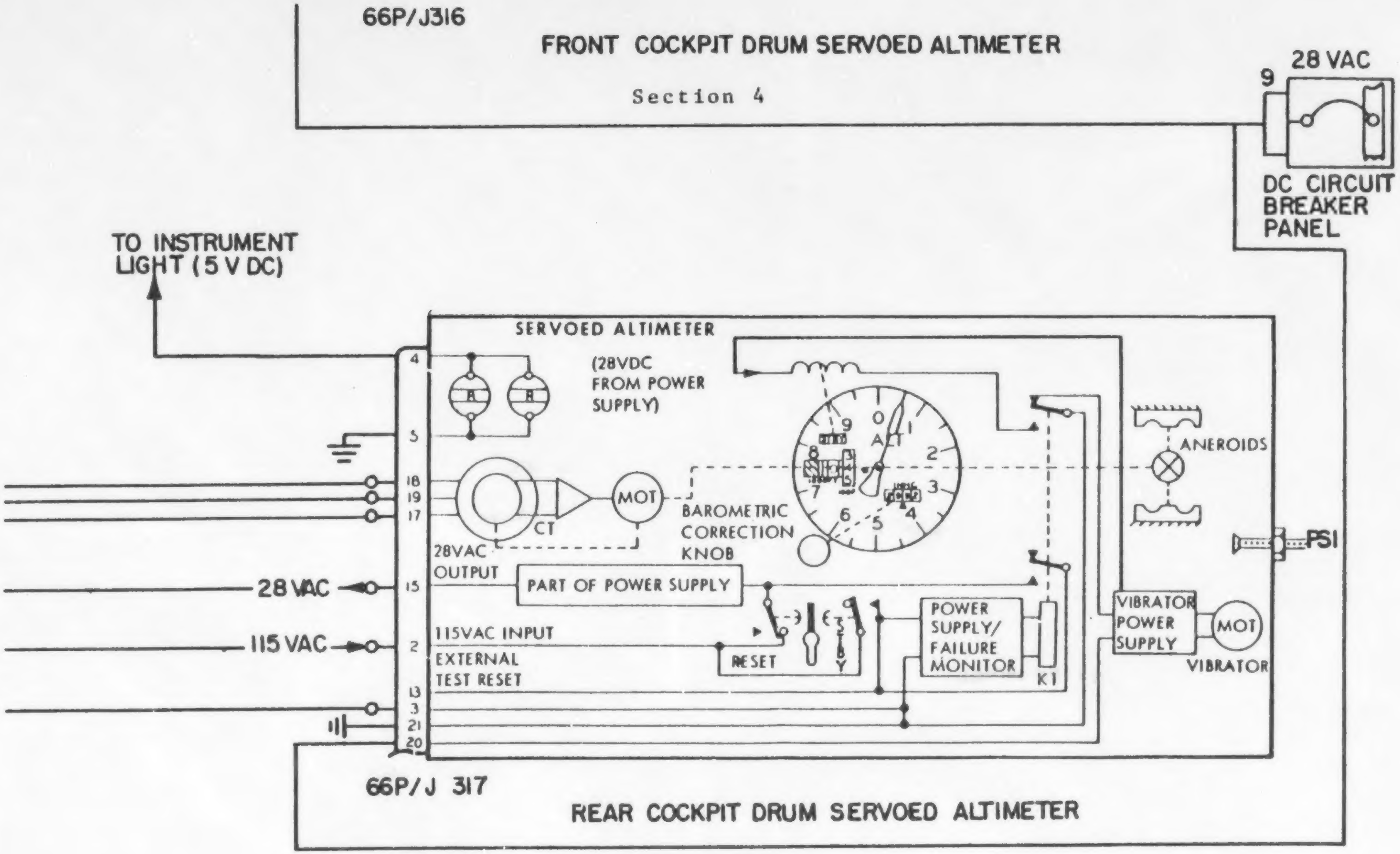

J3
(71P311C)
1
2
5
HP RATE ERROR
INPUT POWER
FAILURE MONITOR
POWER SUPPLY
GEN
PSI
PSI CAPSULE
ROTOR
AMP
M
CALIBRATION CAM
LEAD SCREW
LOG PSI
HP
J2 (71P311B)
7
8
9
5
13
3
10
11
12
1
15
4
1
2
LOG PS
LOG PSI/PS
HP
LOG PS-HP
2 CAM
1 CAM
LOG PT/PS
3
LOG PT
GEN
PT
PT CAPSULE
ROTOR
AMP
M
LEAD SCREW
CALIBRATION CAM
LOG PT
DIGITAL HP ENCODER

ALTITUDE COMPUTER CPU-46/A


LEFT GENERATOR
115 VAC 320-480HZ
F
12
REAR COCKPIT
LEFT CIRCUIT
BREAKER PANEL
TO INSTRUMENT
LIGHTS (5 V DC)
SERVOED ALTIMETER
(28VDC
FROM POWER
SUPPLY)
4
5
18
19
17
CT
MOT
BAROMETRIC
CORRECTION
KNOB
ALT
0
1
2
3
4
5
6
7
8
9
ANEROIDS
PSI
28VAC
OUTPUT
28 VAC
15
PART OF POWER SUPPLY
115 VAC
2
115VAC INPUT
EXTERNAL
TEST RESET
RESET
S
B
Y
POWER
SUPPLY/
FAILURE
MONITOR
K1
VIBRATOR
POWER
SUPPLY
MOT
VIBRATOR
13
3
21
20


CODER-RECIEVER TRANSMITTER
J1
(71P311A)
(66P408 A)
J2
6
7
8
9
10
11
12
13
14
15
22
23
25
26
A1
A2
A4
B1
B2
B4
C1
C2
C4
D2
D4
7
8
9
10
11
12
13
14
15
16
17
SHIFT
REGISTER
(ALTITUDE
LOGIC
INPUT)
IFF MODE C
ALTITUDE TO
GROUND
J1
(66P408 C)

IFF TRANSPONDER


66P/J316
FRONT COCKPIT DRUM SERVOED ALTIMETER
9
28 VAC
DC CIRCUIT BREAKER PANEL
TO INSTRUMENT LIGHT (5 V DC)
SERVOED ALTIMETER
(28VDC FROM POWER SUPPLY)
4
5
18
19
17
CT
MOT
28VAC OUTPUT
BAROMETRIC CORRECTION KNOB
ALT
ANEROIDS
PSI
28 VAC
15
PART OF POWER SUPPLY
115 VAC
2
115VAC INPUT
EXTERNAL TEST RESET
RESET
POWER SUPPLY/ FAILURE MONITOR
K1
VIBRATOR POWER SUPPLY
MOT
VIBRATOR
13
3
21
20
66P/J 317
REAR COCKPIT DRUM SERVOED ALTIMETER

Flight Training Devices & Instrument Branch
Chanute AFB, Illinois

3ABR32531-WB-302
3ABR32532B-WB-402
7 June 1978

LEAK CHECK OF THE TTU-205C/E PRESSURE TEMPERATURE TEST SET

OBJECTIVES

Use this workbook and a TTU-205C/E, perform a leak check of the TTU-205C/E test set with no more than one (1) assist from the lab instructor.

EQUIPMENT

	Basis of Issue
3ABR32531-WB-303	1/student
TTU-205C/E Test Set	1/2 students

PROCEDURE

Use the following procedures to perform an operational check and a leak check of the TTU-205C/E test set.

Caution: Remove all jewelry.

OPERATIONAL CHECK AND LEAK CHECK OF THE TTU-205C/E

1. Preparation of TTU-205C/E test set for operation.

   a. Adjust test set controls and position test set switches to the initial settings as shown on page 2.

   b. Connect 115 volt AC 400 Hz power cord to power cable.

Supersedes 3ABR32531-WB-303 and 3ABR32632B-WB-401A, 14 March 1975.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 400; TTVSA - 2

Designed for ATC Course Use. Do Not Use On the Job.

SWITCH OR CONTROL	POSITION
Power	OFF
Modulation Frequency HZ	OFF
Modulation Amplitude	0
Mach Limit Disabled-Normal	Normal
Mach Limit Set	2.8
Alt. Leak Test Switch	OFF
Airspeed Leak Test Switch	OFF
Altitude Trim Control	Center of Travel (5 turns total)
Airspeed Trim Control	Center of Travel (1 turn total)
Airspeed Knots	100
Airspeed Rate Knots/Minute	250
Altitude X 1000 Feet	0
Altitude Rate X 100 Feet/Minute	35
Altitude Hold	Normal
Normal/Read Ext	Normal
Pitot Pressure Vent	Closed (CW)
Static Pressure Vent	Closed (CW)

Figure 1.

Read this page before proceeding with test set start up.

Note: Before proceeding any further, read the instructions given below for abnormal pressure conditions. After reading the information on abnormal pressure conditions, proceed with the procedure given in item 2 for test set startup procedures.

ABNORMAL PRESSURE CONDITIONS

In the event that the altitude and/or airspeed range of the test set is exceeded when the power switch is turned on, the appropriate warning lamp will illuminate, the green lights will extinguish and the pump will stop. To correct the abnormal pressure conditions accomplish the following:

1. Move the switch from NORMAL to READ EXT mode. Blower will stop running, and all power is removed from the test set except the ALTITUDE and AIRSPEED indicators.

2. Slowly open the pitot VENT valve until the airspeed indicator shows that pitot pressure is near ambient pressure.

3. Slowly open the static VENT valve until the altitude indicator shows that altitude is near ambient pressure.

Note: The pitot pressure line should be vented to atmosphere before venting the static pressure line. This prevents creating a negative differential pressure. In any event, check valves in test set that are connected between the pitot and static output lines prevent more than 1/2" Hg negative differential pressure from being developed. This protection is present whether the test set power is ON or OFF or whether the test set is in NORMAL or READ EXTERNAL modes of operation.

4. Close the static and pitot vent valves and restore operation by adjusting the airspeed and altitude controls to ambient settings, and place the test switch from READ EXT to NORMAL.

The MACH LIMIT LAMP (RED) will illuminate whenever an airspeed is commanded that exceeds the limit value corresponding to the existing altitude and the setting of the LIMIT SET control. The airspeed counter will run up only to the limit value, not up to the command value. The mach limit conditions may be corrected by:

1. Reducing the commanded airspeed.

2. Reducing the actual altitude.

3. Increasing the setting of the MACH LIMIT control.

Note: If a mach number greater than 3.00 is desired, place the mach limit switch in the DISABLED position.

4. Perform Test Set Startup as follows:

    a. Position test set power switch to ON.

        RESULTS: Test set power lamp shall light. Two green READY lights shall light in approximately 1 minute.

    b. Allow test set 10-minute warmup time and allow ALTITUDE FEET and AIRSPEED KNOTS counters to stabilize before proceeding.

    c. Cycle ALTITUDE and AIRSPEED upscale and downscale (pneumatic cycling) for a minimum of two complete cycles as follows:

        (1) Set ALTITUDE RATE X 1000 FEET/MINUTE to 35 and ALTITUDE X 1000 FEET to 75 and allow ALTITUDE FEET counter to read approximately 75,000 feet and settle.

Note: Do not change previous settings of AIRSPEED controls during altitude cycling.

(2) Set ALTITUDE X 1000 FEET to SEA LEVEL and allow counter to settle to approximately zero feet.

(3) Repeat substeps 1 and 2 at least one time.

(4) Return ALTITUDE RATE X 1000 FEET/MINUTE and ALTITUDE X 1000 FEET to initial settings shown in figure 1.

(5) Set AIRSPEED RATE KNOTS/MINUTE to 400.

(6) Set AIRSPEED KNOTS to 950. Allow AIRSPEED KNOTS counter to reach approximately 950 knots and settle.

Note: Do not change previous settings of ALTITUDE controls during cycling of airspeed.

(7) Set AIRSPEED KNOTS to 100. Allow AIRSPEED KNOTS counter to settle at approximately 100 knots.

(8) Repeat substeps 6 and 7 at least one time.

(9) Return AIRSPEED RATE KNOTS/MINUTE and AIRSPEED KNOTS to initial settings in figure 1. Allow AIRSPEED KNOTS counter to stabilize.

5. Perform test set leak check as follows:

a. Adjust test controls to 40,000 feet and 700 knots. Allow test set counters at least 10 seconds to stabilize.

b. Position LEAK TEST ALT switch to ON and allow altitude FEET counter to stabilize. Leave switch in this position for five minutes.

RESULTS: (1) Amber ALT leak test lamp will light.

(2) Green READY lamp will go out.

c. Determine leak rate by observing ALTITUDE FEET counter for five minutes. After five minutes, record ALTITUDE FEET counter indication.

RESULTS: Altitude Feet counter shall not have changed more than 250 feet.

Sat. ______ Unsat. ______

d. Return LEAK TEST ALT switch to OFF.

RESULTS: (1) Amber lamp will go out immediately.

(2) Green STATIC PRESSURE READY lamp will light after approximately one minute.

e. Position the LEAK TEST AS switch to ON and allow AIRSPEED KNOTS counter to stabilize. Leave switch in this position for five minutes.

RESULTS: (1) Amber AS lamp will light.

(2) Green READY lamp will go out.

f. Determine leak rate by observing AIRSPEED KNOTS counter for five minutes. Record AIRSPEED KNOTS counter indication.

RESULTS: AIRSPEED KNOTS counter shall not have changed more than five knots.

Sat. ______ Unsat. ______

g. Return LEAK TEST AS switch to OFF.

RESULTS: (1) Amber light will go out immediately.

(2) Green PITOT PRESSURE READY lamp will light after approximately one minute.

Caution: Do not use a test set that fails the above leak check to supply inputs for test of the air data computer systems. If test set fails leak check, repair or replace test set.

6. Test Set Shutdown, TTU-205C/E

a. Perform test set shutdown when any of the following conditions exist:

Note: For normal shutdown procedures refer to paragraph 4.

(1) When any pneumatic connection is to be opened.

(2) When test set power switch is to be positioned to OFF.

(3) When test procedures are complete.

(4) When test power has been interrupted.

(5) When any of the test set warning indicator lamps (4), except Mach Limit, light.

(6) When green READY light goes out and no warning indicator lamp lights.

6. Perform Test Set Shutdown as follows:

a. Rotate ALTITUDE X 1000 FEET control to Sea Level.

b. Adjust AIRSPEED KNOTS control to 100 knots.

Note: If at high altitude and high airspeed, decrease altitude before airspeed.

c. Allow counters to stabilize.

d. Slowly rotate airspeed (P_t) vent fully counterclockwise to open.

Note: If test pneumatic lines are connected to aircraft pitot static probe adapter, do not proceed with shutdown until airspeed (P_t) vent has been full opened for a minimum of one minute.

e. Slowly rotate altitude (P_s) vent fully counterclockwise to open. Allow pressure to bleed down completely.

f. Position test set power switch to OFF.

Caution: Allow at least two minutes after test set shutdown before restarting the test set.

g. Disconnect electrical power source.

WORKBOOK

3ABR32531-WB-302A
3ABR32632B-WB-402A

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

INSPECTION, OPERATIONAL CHECK AND BENCH CHECK AIMS

9 June 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

Flight Training Devices/Instrument Branch
Chanute AFB, Illinois

3ABR32531-WB-302A
3ABR32632B-WB-402A

INSPECTION, OPERATIONAL CHECK AND BENCH CHECK AIMS

OBJECTIVES

Given a workbook, TO extract, test equipment and trainer, perform an inspection, operational check and bench check of an automatic altitude reporting system with a minimum of 100% accurate workbook responses.

EQUIPMENT

	Basis of Issue
TTU-205C/E	1/2 students
TTU-229/E	1/2 students
CPU-46/A	1/2 students
AAU-19/A Altimeter	1/2 students

PROCEDURE

Remove all jewelry. Read this workbook carefully, it will guide you through the bench check.

Special Note: Check figure 3-1 of TO extract 5F5-4-13-22 to make sure all equipment is connected according to the diagram. The pitot pressure and pitot-static control panel may be used in place of the pressure temperature set, if necessary, and will be used in conjunction with 3ABR32531-HO-303.

Check the type computer assigned to you by your instructor. The type of computer will be found on the data plate on the side of the computer chassis and the type of aircraft is shown on the top and side of the computer.

Type of computer ____________________. Type of aircraft used

____________________, ____________________.

1. Perform visual inspection in accordance with para 3-5 of TO extract.

   a. Visual Inspection - Satisfactory _____. Unsatisfactory _____.

2. Set up TTU-205/E IAW table 3-1 of TO extract.

3. Set up TTU-229/E IAW table 3-1 of TO extract.

   Read all cautions and notes.

4. Perform pressure leak check IAW para 3-8 of TO extract.

   a. Pressure Leak Check. Satisfactory _____. Unsatisfactory _____

Supersedes 3ABR32531-WB-302A, 13 June 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360TCHTG/TTGU-F - 300; TTVSA - 1

5. Perform Scale Error Test IAW para 3-9a, b, c, d, e, and f of TO extract and table 3-4 of TO extract, that pertains to the computer and type of A/C you are working with.

Note: Be sure you are using the chart for the type of computer assigned to you.

a. Satisfactory ______ Unsatisfactory ______

b. Satisfactory ______ Unsatisfactory ______

c. Satisfactory ______ Unsatisfactory ______

d. Satisfactory ______ Unsatisfactory ______

e. Satisfactory ______ Unsatisfactory ______

f. Satisfactory ______ Unsatisfactory ______

g. Satisfactory ______ Unsatisfactory ______

6. Perform Encoder Diode Test IAW para 3-10 of TO extract.

a. Encoder Diode Test - Satisfactory ______
Unsatisfactory ______

7. Perform Encoder Transition Accuracy Test IAW para 3-11 and Table 3-2 of TO extract.

a. Encoder Transition Accuracy Test - Satisfactory ______
Unsatisfactory ______

8. Perform Failure Warning Circuit Test IAW para 3-12 of TO extract.

a. Failure Warning Circuit Test - Satisfactory ______
Unsatisfactory ______

9. Perform Test Set Shutdown IAW para 3-14e through 3-14j of TO extract.

a. Test Set Shutdown - Satisfactory ______
Unsatisfactory ______

10. Perform shutdown of TTU-229/E IAW para 3-15 of TO extract.

Note: Do not disconnect any hoses or cables from the computer of TTU-229/E Test Set.

a. Test Set Shutdown - Satisfactory ______
Unsatisfactory ______

11. Call instructor.

12. Disconnect TTU-205C/E and TTU-229/E power cords as per instructions from innstructor.

13. Disconnect P_t and P_s hoses from TTU-205C/E test set as per instructions from instructor.

1294

SECTION III

BENCH TEST PROCEDURES

3-1. GENERAL.

3-2. The following checkout procedures cover Field (Intermediate) Level (Bench) Testing of the computers.

3-3. The computer, except part number A4370000050, shall be connected to the TTU-205 and the TTU-229/E test sets as shown in figure 3-1. Control settings shall be as indicated in table 3-1.

3-3A. Part number A4370000050 computer shall be connected to the TTU-205 and the TTU-229/E test sets, and adapter box and cable assembly as shown in figure 3-2. Control settings shall be as indicated in table 3-1, and the adapter box switch shall be set to 3-1. The adapter box and cable assembly must be connected for all tests involving the part number A4370000050 computer.

3-4. VISUAL INSPECTION.

3-5. A visual inspection shall be performed on the computer to check the following:

a. No damage to case, connector, or fuses shall be visible.

b. Shock mounts shall permit free motion.

c. Pressure and electrical connectors shall be free from dirt and other foreign matter.

d. Electrical connector pins shall be straight and inserted to full depth.

e. Aircraft identification markings on the computer shall agree with the applicable aircraft designations associated with tables 3-3 through 3-18 contained in this procedure.

3-6. TEST ENVIRONMENT.

3-7. The test area shall be clean and tests conducted at room temperature and pressure.

WARNING

Operator should wear ear plugs when operating TTU-205 tester. Acoustical noise level of tester can impair hearing.

Failure to release the pressure relief valve on test set TTU-229/E before removing the carrying case lid may cause possible damage to the test set and injury to personnel as a result of pressure differential.

CAUTION

When connecting the TTU-229/E cables to a computer having clocked connectors, make sure the key of the TTU-229/E cable universal connectors is in the twelve o'clock position. Extreme caution should be exercised to assure key and keyway are properly aligned. Misalignment can easily result if key and keyway are not closely observed while connecting.

3-8. PRESSURE LEAK TEST.

a. Turn TTU-205 power switch ON.

b. Set altitude control to 40,000 feet and airspeed control to 600 knots on the computer with [illegible] TTU-205.

c. Set altitude rate at 5000 feet per minute.

NOTE

When performing step d for type A4370000050 ensure that adapter box switch is set to B1 position.

d. Set the airspeed rate at 100 knots/minute. After stabilization, place the leak test switches on the TTU-205 in the ON position for a period of one minute. During this time the altitude readout on the TTU-205 shall not change by more than 100 feet and the airspeed change shall not exceed two knots.

e. Return the altitude control to zero altitude and the airspeed control to 50 knots.

1333

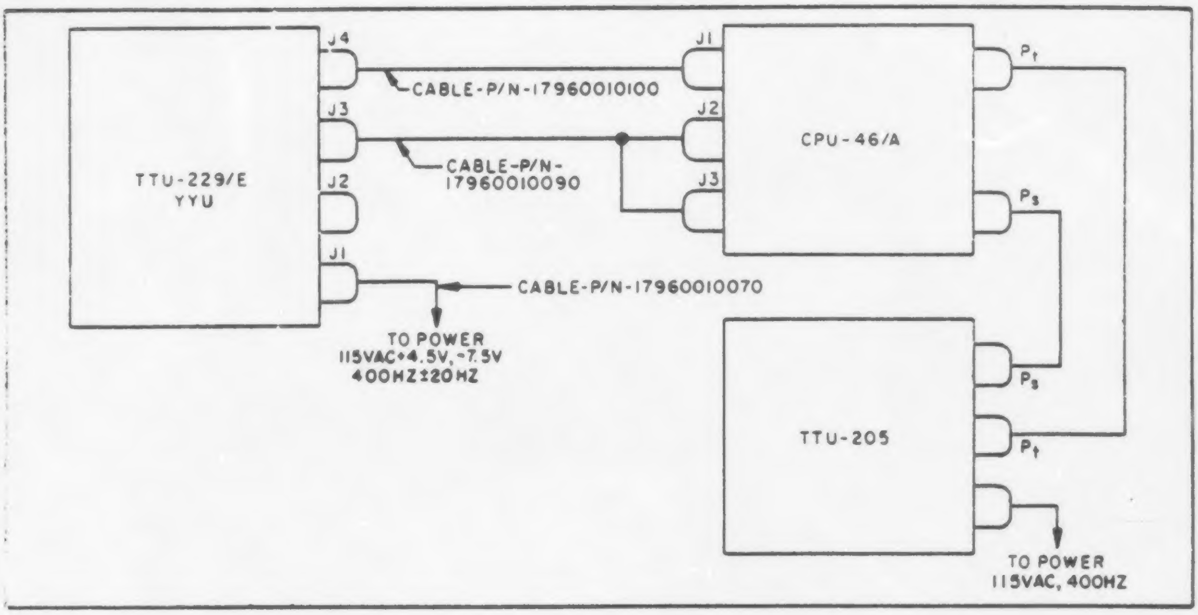

TTU-229/E
YYU
J4
J3
J2
J1
CABLE-P/N-17960010100
CABLE-P/N-
17960010090
CABLE-P/N-17960010070
TO POWER
115VAC+4.5V,-7.5V
400HZ±20HZ
J1
J2
J3
CPU-46/A
Pt
Ps
Ps
Pt
TTU-205
TO POWER
115VAC, 400HZ

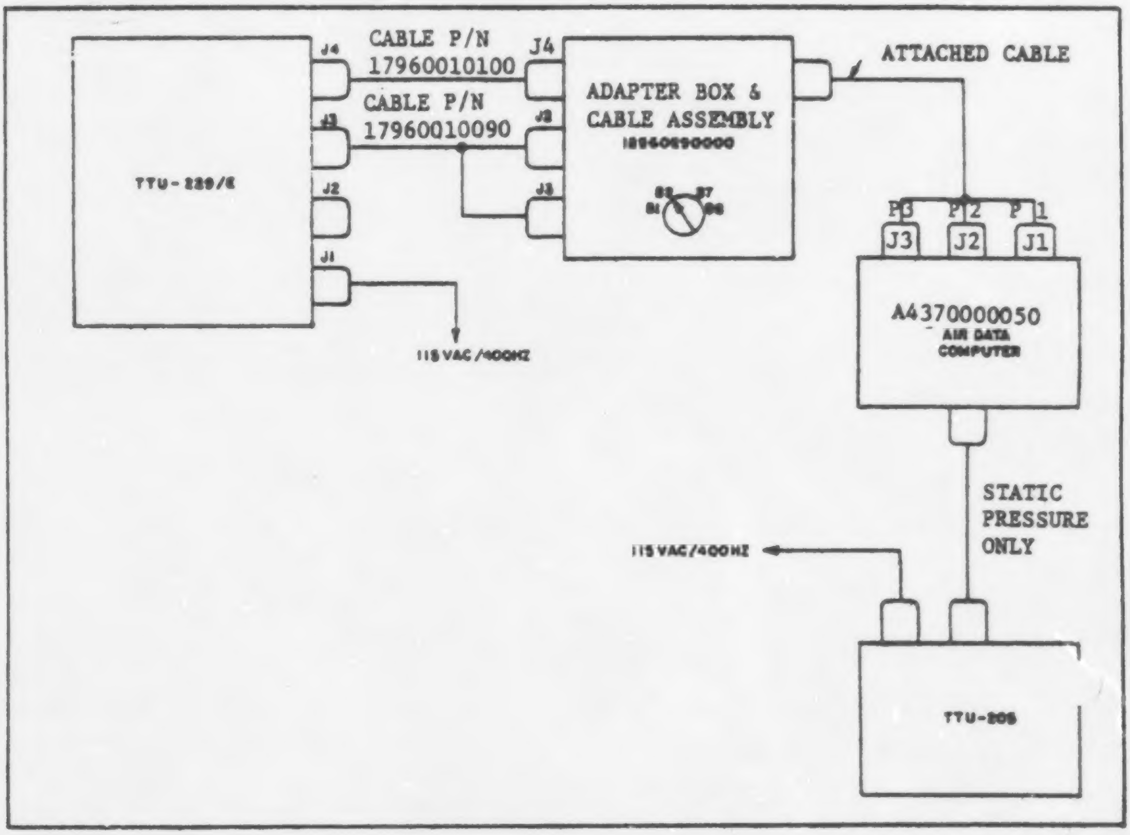
Figure 3-1. Bench Set-Up

TABLE 3-1. INITIAL TEST EQUIPMENT CONTROL SETTINGS

TTU-205 Pressure-Temperature Test Set	TTU-229/E Altitude Encoding Altitude Transducer Test Set
Controls shall be set in the following manner:	Controls shall be set in the following manner:
a. Power switch - OFF	a. Power switch - OFF
b. Ps and Pt equalizers - CLOSED	b. Synchro selector - PILOT
c. Mach limit - 2.0 Mach*	c. Lighting switch - OFF
d. Pressure modulation frequency - OFF	d. Altimeter servo switch - NORMAL
e. Pressure modulation amplitude - 0	e. Vibrator switch - ENABLE
f. Altitude control - Approximately field elevation	f. Encoder readout - NORMAL
g. Altitude rate control - 2000 ft/min	g. Induced error - Zero feet
h. Altitude fine adjust - Center of travel	h. Turn power to ON
i. Airspeed control - 100 knots	i. Observation: The "Test Set Power", "Pilot", "Co-Pilot", and "Computer Operate" indicators on the TTU-229/E will illuminate. Encoder display and synchro display will activate.
j. Airspeed rate control - 100 knots per minute	j. Use the "Synchro Reset" to set the TTU-229/E altimeter display to approximately station altitude.
k. Airspeed fine adjust - Center of travel	

CAUTION

*The differential pressure applied to the computer shall not exceed the value for Mach No. 2.0. Pt shall always be greater than Ps.


TTU-229/E
J4
J3
J2
J1
CABLE P/N
17960010100
CABLE P/N
17960010090
J4
J2
J3
ADAPTER BOX &
CABLE ASSEMBLY
ATTACHED CABLE
115 VAC/400HZ
P3
P2
P1
J3
J2
J1
A4370000050
AIR DATA
COMPUTER
STATIC
PRESSURE
ONLY
115 VAC/400HZ
TTU-205

4370-4-29

Figure 3-2. Bench Set Up for Part Number A4370000050

3-9. SCALE ERROR TEST

NOTE

Scale error tests for part number A4370000050 shall be performed according to paragraph 3-9A.

a. Set the TTU-205 airspeed and altitude controls to the first test point value as specified for the applicable computer under test in tables 3-3 through 3-14, columns 1 and 2. Before each reading is taken, gently tap the instrument.

b. Verify that the encoder readout display on the TTU-229/E is within 100 feet of altitude synchro display. The rate of change of pressures during testing shall not exceed 6000 feet per minute change in height indication.

c. Record the "Pilot" reading of the "Synchro Display" of the TTU-229/E. The reading shall match corresponding reading (column 3, tables 3-3 through 3-14) within the tolerance listed for the appropriate computer (column 4, tables 3-3 through 3-14).

Record the illuminated encoder lights on the TTU-229/E. This series of lights shall match one of the possible combinations listed in column 5 tables 3-3 through 3-14.

d. Position the TTU-229/E "Synchro Selector" to "Co-Pilot". Record the reading of the "Co-Pilot" output which shall be within 20 feet of the "Pilot" readings.

e. Reposition "Synchro Selector" switch to "Pilot" position.

f. Set the TTU-205 airspeed and altitude controls to the next test point as specified in tables 3-3 through 3-14, columns 1 and 2 and repeat steps c and d until all test points are taken and recorded in both the ascending and descending directions.

3-9A. SCALE ERROR TESTS FOR PART NUMBER A4370000050.

CAUTION

Do not select synchro B-8 when above 5,000 feet. This will cause the TTU-229/E to index to the wrong 10,000 indication.

a. Select B-1 on the Adapter Box and Cable Assembly (P/N 18960890000), and adjust the TTU-205 ALTITUDE CONTROL to obtain the test pressures listed in table 3-15. Increasing and decreasing altitudes shall be brought up to but not exceeding each test point.

NOTE

Record B-1 synchro readings at 0, 1500, 3000 and 15,000 feet. These readings will be used later.

b. Check scale error of synchro B-2 and B-7 by adjusting the TTU-205 ALTITUDE CONTROL to obtain the test pressures listed in table 3-16. The output readings of synchro B-2 and B-7 shall not differ from that of synchro B-1 by more than ±25 feet.

NOTE

Reading for synchro B-1, B-2 and B-7 can be obtained during the same run by switching to the required synchro outputs at the appropriate test altitudes.

c. Check scale error of synchro B-8 by adjusting the TTU-205 ALTITUDE CONTROL to obtain the test pressures listed in table 3-17. The output of synchro B-8 shall not differ from that of synchro B-1 by more than that shown in table 3-17.

3-10. ENCODER DIODE TEST. This test determines if a diode malfunction has occurred in any one of the encoder lines of the computer and may be conducted in conjunction with the Encoder Transition Accuracy Test, paragraph 3-11.

NOTE

Steps a through n shall be used, for the part number A4370000050 when the adapter switch box and cable assembly are in the line and switch is set to B1.

TABLE 3-2. TRANSITION ALTITUDES

Nominal Increasing TTU-229/E Altitude Indication	Encoder Readout TTU-229/E Transition Altitude	Nominal Decreasing TTU-229/E Altitude Indication
950	1000	1050
2950	3000	3050
4950	5000	5050
9950	10, 000	10, 050
19, 950	20, 000	20, 050
24, 950	25, 000	25, 050
49, 950	50, 000	50, 050
59,950	60, 000	60, 050

a. Set the TTU-229/E controls to the positions as stated in table 3-1.

b. Set the TTU-205 airspeed control to 50 knots.

c. Set the TTU-205 altitude control until the "Encoder Readout" on the TTU-229/E reads 23, 200 feet.

d. Note that indicator lights A_1, A_4, and C_1 are illuminated.

e. Rotate the "Encoder Readout Selector" switch to the "Self Test" position. The encoder readout should read 40, 000 feet.

f. For Bendix computers leave the "Encoder Readout Selector" switch in the "Self Test" position for approximately one minute before moving the switch to the "Diode Test" position. For Kollsman computers leave the "Encoder Readout Selector" switch in the "Self-Test" position for approximately 5-10 seconds before moving the switch to the "Diode Test" position.

g. Rotate the "Encoder Readout Selector" to the "Diode Test" position. Indicator lights A_1, A_4, and C_1 should extinguish.

h. Return "Encoder Readout Selector" switch to the "Normal" position. Indicator lights A_1, A_4, and C_1 should illuminate.

i. Adjust the TTU-205 altitude control until the "Encoder Readout" on the TTU-229/E reads 49, 600 feet.

j. Note that indicator lights D_4, A_2, B_1, B_2, B_4, C_2, and C_4 illuminate.

k. Rotate the "Encoder Readout Selector" switch to the "Self Test" position. The encoder readout should read 40, 000 feet.

l. Leave the "Encoder Readout Selector" switch in the "Self Test" position for approximately one minute before moving the switch to the "Diode Test" position.

m. Rotate "Encoder Readout Selector" switch to the "Diode Test" position. Indicator lights D_4, A_2, B_1, B_2, B_4, C_2, and C_4 should extinguish.

n. Rotate the "Encoder Readout Selector" switch to the "Normal" position. Indicator lights D_4, A_2, B_1, B_2, B_4, C_2, and C_4 should illuminate.

3-11. ENCODER TRANSITION ACCURACY TEST. This test may be conducted in conjunction with the scale error test, Paragraph 3-9.

NOTE

Encoder transition accuracy test for the A4370000050 shall be performed according to paragraph 3-11A.

a. Set the TTU-205 airspeed control to 50 kno and the altitude control to zero.

b. Adjust TTU-205 altitude control to apply increasing and decreasing altitudes to the transition altitudes listed in table 3-2.

c. The rate of altitude change shall be the slowest rate attainable on the TTU-205 as the transition altitude is approached.

d. At the moment of transition, which is denoted by illumination of the 1000-foot indicator light and a short-duration tone from the headset, the altimeter indication on the TTU-229/E shall indicate within 50 feet of the nominal indication specified in table 3-2.

3-11A. ENCODER TRANSITION ACCURACY TEST FOR PART NUMBER A4370000050. This test may be conducted in conjunction with the scale error test, paragraph 3-9A.

a. Select synchro B-1 and adjust the TTU-205 ALTITUDE CONTROL to zero, the static pressure should then be run slowly through the transition values listed in table 3-2. The output at transition shall be within the values listed in table 3-2.

3-11B. POSITION ERROR FOR PART NUMBER A4370000050.

a. Check position error of type A4370000050 computer by rotating the computer 90 degrees about its normal mounting position in each of the four axes. At the test points in table 3-18. The position error must not exceed the values listed in table 3-18. See figure 3-3 for orientation.

3-12. FAILURE WARNING CIRCUIT TEST.

a. Set the TTU-229/E controls to the positions as stated in table 3-1.

b. Set the TTU-205 altitude control to zero altitude.

NOTE

The altitude readout on the TTU-229/E may drift during this test, but this drift should not be considered a fault.

c. Momentarily position the TTU-229/E "Failure Warning" switch to "Failure Warning" position. The "Failure Warning" panel indicator should illuminate and the "Computer Operate" indicator should extinguish. This will assure that the computer failure warning circuitry is operating properly.

d. Set TTU-205 altitude control to station pressure altitude.

3-13. TEST SETS TTU-205 AND TTU-229/E SHUTDOWN PROCEDURES.

3-14. TEST SET TTU-205 SHUTDOWN. This procedure shall be used whenever one of the following conditions occurs:

a. Any pneumatic connection is to be changed.

b. Prior to switching OFF on completion of tests.

c. Immediately following an interruption of power.

d. Immediately following an abnormal pressure condition as indicated by any of the three red lamps.

e. The test set TTU-205 shall be shutdown as follows:

f. Rotate AIRSPEED control fully counterclockwise (50 knots).

g. Rotate ALTITUDE control to local ambient altitude.

h. Check PRESSURE MODULATION controls OFF, i.e., FREQUENCY control OFF, AMPLITUDE control to 0. Allow pressure to stabilize until counters steady.

i. Open (counterclockwise) the Ps EQUALIZER and Pt EQUALIZER controls. Allow pressure to run down and stabilize at ambient as indicated by the counters.

j. Switch POWER OFF.

3-15. TEST SET TTU-229/E.

a. Secure the test set by setting the switches and controls to the positions given in table 3-1.

b. Disconnect hoses and cables from the computer and the test sets and return to stowage unless required for further operation.

3-16. DEFINITIONS.

a. Pressure Altitude - Altitude in a standard atmosphere corresponding to a given atmospheric pressure actually encountered.

b. Indicated Static Pressure (Psi) - Actual static pressure sensed by altimeter aneroids.

c. Indicated Pressure Altitude (Hi) - That altitude displayed by a standard barometric altimeter, i.e., height above standard sea level pressure (29.92 inches of mercury).

d. Corrected Pressure Altitude (Hc) - Same as indicated pressure altitude except a predetermined correction is applied by the computer to correct for static pressure error.

e. Static Pressure Error (Psi-Ps) - That error resulting from design and location of pressure pickup in conjunction with the speed of the aircraft.

NOTE

When referring to Column (5) of Tables 3-3 through 3-14 the computer should indicate one of the alpha-numeric code outputs, not all of them.

TABLE 3-3. SCALE ERROR TOLERANCES, TYPE NO. CPU-46A/A-1, CPU-46/A-1

Aircraft F-101B, F-101F				
TTU-205 Input		TTU-229/E Output		
(1) Indicated Speed (Knots)	(2) Indicated Pressure Altitude (Ft)	(3) Calibrated Pressure Altitude (Ft)	(4) Total Tolerance (Ft ±)	(5) Code Outputs
66	-11	0	36	B_2 B_4 C_2 C_4 B_2 B_4 C_2 B_2 B_4 C_1 C_2
199	132	0	49	B_2 B_4 C_2 C_4 B_2 B_4 C_2 B_2 B_4 C_1 C_2
333	-459	0	56	B_2 B_4 C_2 C_4 B_2 B_4 C_2 B_2 E_4 C_1 C_2
197	369	500	49	B_2 C_1 C_2 B_2 C_2 B_2 C_2 C_4
195	869	1000	49	B_1 B_2 C_2 C_4 B_1 B_2 C_2 B_1 B_2 C_1 C_2
190	2370	2500	49	B_1 C_1 C_2 B_1 C_2 B_1 C_2 C_4
181	4873	5000	49	A_4 B_2 C_2 C_4 A_4 B_2 C_2 A_4 B_2 C_1 C_2
212	4732	5000	52	A_4 B_2 C_2 C_4 A_4 B_2 C_2 A_4 B_2 C_1 C_2

TABLE 3-3. SCALE ERROR TOLERANCES, TYPE NO. CPU-46A/A-1, CPU-46/A-1 (Cont)

Aircraft F-101B, F-101F				
TTU-205 Input		TTU-229/E Output		
(1) Indicated Speed (Knots)	(2) Indicated Pressure Altitude (Ft)	(3) Calibrated Pressure Altitude (Ft)	(4) Total Tolerance (Ft ±)	(5) Code Outputs
303	4557	5000	56	$A_4 B_2 C_2 C_4$ $A_4 B_2 C_2$ $A_4 B_2 C_1 C_2$
396	4238	[illegible]	63	$A_4 B_2 C_2 C_4$ $A_4 B_2 C_2$ $A_4 B_2 C_1 C_2$
290	7065	[illegible]	55	$A_2 A_4 B_4 C_1 C_2$ $A_2 A_4 B_4 C_2$ $A_2 A_4 B_4 C_4$
221	97[illegible]1	[illegible]	51	$A_2 A_4 B_1 B_4 C_2 C_4$ $A_2 A_4 B_1 B_4 C_2$ $A_2 A_4 B_1 B_4 C_1 C_2$
449	8785	10,000	63	$A_2 A_4 B_1 B_4 C_4$ $A_2 A_4 B_1 B_4 C_2$ $A_2 A_4 B_1 B_4 C_1 C_2$
275	19,421	20,000	91	$A_1 A_2 A_4 B_1 B_2 B_4 C_2 C_4$ $A_1 A_2 A_4 B_1 B_2 B_4 C_2$ $A_1 A_2 A_4 B_1 B_2 B_4 C_1 C_2$
304	28,964	30,000	145	$A_1 B_4 C_4$ $A_1 B_4 C_4 C_2$ $A_1 B_4 C_2$ $A_1 B_4 C_1 C_2$ $A_1 B_4 C_1$
510	33,440	35,000	283	$D_4 A_1 B_1 C_4$ $D_4 A_1 A_4 B_1 C_4$ $D_4 A_1 A_4 B_1 C_4 C_2$ $D_4 A_1 A_4 B_1 C_2$ $D_4 A_1 A_4 B_1 C_1 C_2$ $D_4 A_1 A_4 B_1 C_1$ $D_4 A_1 A_4 B_1 B_4 C_1$
431	34,857	35,000	126	$D_4 A_1 A_4 B_1 C_4 C_2$ $D_4 A_1 A_4 B_1 C_2$ $D_4 A_1 A_4 B_1 C_1 C_2$
386	39,859	40,000	144	$D_4 A_1 A_2 A_4 B_2 B_4 C_4$ $D_4 A_1 A_2 A_4 B_2 B_4 C_4 C_2$ $D_4 A_1 A_2 A_4 B_2 B_4 C_2$ $D_4 A_1 A_2 A_4 B_2 B_4 C_1 C_2$ $D_4 A_1 A_2 A_4 B_2 B_4 C_1$
192	49,023	50,000	212	$D_4 A_2 B_1 B_2 B_4 C_4$ $D_4 A_2 B_1 B_4 C_4$ $D_4 A_2 B_1 B_4 C_2 C_4$ $D_4 A_2 B_1 B_4 C_2$ $D_4 A_2 B_1 B_4 C_1 C_2$ $D_4 A_2 B_1 B_4 C_1$ $D_4 A_2 B_1 C_1$
151	59,023	60,000	248	$D_4 B_1 B_4 C_4$ $D_4 B_1 B_2 B_4 C_4$ $D_4 B_1 B_2 B_4 C_2 C_4$ $D_4 B_1 B_2 B_4 C_2$ $D_4 D_1 B_2 B_4 C_1 C_2$ $D_4 B_1 B_2 B_4 C_1$ $D_4 B_1 B_2 C_1$
Note: Tests should be run upscale and downscale.				

TABLE 3-4. SCALE ERROR TOLERANCES, TYPE NO. CPU-46A/A-3, CPU-46/A-3

	Aircraft T-38, F-5B				
	TTU-205 Input		TTU-229/E Output		
	(1) Indicated Speed (Knots)	(2) Indicated Pressure Altitude (Ft)	(3) Calibrated Pressure Altitude (Ft)	(4) Total Tolerance (Ft ±)	(5) Code Outputs
A	50	-12	0	36	B2 B4 C2 C4 B2 B4 C2 B2 B4 C1 C2
	331	-46	0	36	B2 B4 C2 C4 B2 B4 C2 B2 B4 C1 C2
	197	457	500	36	B2 C1 C2 B2 C2 B2 C2 C4
	135	957	1000	36	B1 B2 C2 C4 B1 B2 C2 B1 B2 C1 C2
B	190	2457	2500	36	B1 C1 C2 B1 C2 B1 C2 C4
	181	4958	5000	36	A4 B2 C2 C4 A4 B2 C2 A4 B2 C1 C2
	242	4953	5000	36	A4 B2 C2 C4 A4 B2 C2 A4 B2 C1 C2
C	303	4956	5000	36	A4 B2 C2 C4 A4 B2 C2 A4 B2 C1 C2
	365	4961	5000	36	A4 B2 C2 C4 A4 B2 C2 A4 B2 C1 C2
	290	7457	7500	36	A2 A4 B4 C1 C2 A2 A4 B4 C2 A2 A4 B4 C4
	221	9954	10000	36	A2 A4 B1 B4 C2 C4 A2 A4 B1 B4 C2 A2 A4 B1 B4 C1 C2
	449	9984	10000	38	A2 A4 B1 B4 C2 C4 A2 A4 B1 B4 C2 A2 A4 B1 B4 C1 C2
D	275	19965	20000	71	A1 A2 A4 B1 B2 B4 C2 C4 A1 A2 A4 B1 B2 B4 C2 A1 A2 A4 B1 B2 B4 C1 C2

Note: Tests should be run upscale and downscale.

TABLE 3-4. SCALE ERROR TOLERANCES, TYPE NO. CPU-46A/A-3, CPU-46/A-3 (Cont)

Aircraft T-38, F-5B				
TTU-205 Input		TTU-229/E Output		
(1) Indicated Speed (Knots)	(2) Indicated Pressure Altitude (Ft)	(3) Calibrated Pressure Altitude (Ft)	(4) Total Tolerance (Ft ±)	(5) Code Outputs
E 304	29986	30000	108	A1 B4 C2 C4 A1 B4 C2 A1 B4 C1 C2
386	35469	35000	174	D4 A1 A4 B1 C4 D4 A1 A4 B1 C4 C2 D4 A1 A4 B1 C2 D4 A1 A4 B1 C1 C2 D4 A1 A4 B1 C1
F 298	40068	40000	150	D4 A1 A2 A4 B2 B4 C4 D4 A1 A2 A4 B2 B4 C4 C2
				D4 A1 A2 A4 B2 B4 C2 D4 A1 A2 A4 B2 B4 C1 C2 D4 A1 A2 A4 B2 B4 C1
G 205	50000	50000	180	D4 A2 B1 B4 C4 D4 A2 B1 B4 C2 C4 D4 A2 B1 B4 C2 D4 A2 B1 B4 C1 C2 D4 A2 B1 B4 C1
110	59969	60000	211	D4 B1 B2 B4 C4 D4 B1 B2 B4 C2 C4 D4 B1 B2 B4 C2 D4 B1 B2 B4 C1 C2 D4 B1 B2 B4 C1
Note: Tests should be run upscale and downscale.				

BENCH CHECK OF AAU-19/A ALTIMETER

1. Perform a visual inspection of the AAU-19/A altimeter IAW para 4-a of TO extract 5F3-3-15-22.

Visual Inspection - Satisfactory ______ Unsatisfactory ______

2. Check figure 4-1 of TO extract to make sure the equipment is connected electrically according to the diagram.

3. Set the TTU-229/E controls according to table 4-1 of TO extract.

4. Set the TTU-205C/E controls according to table 4-2 of TO extract.

5. Read and follow instructions in para 4-20 of TO extract.

6. Read and follow instructions in para 4-21 of TO extract.

7. Read and follow instructions in para 4-22 of TO extract.

8. Read and follow instructions in para 4-23 of TO extract.

   a. Perform Leak Check IAW para 4-23 of TO extract.

   b. Leak Check - Satisfactory ______. Unsatisfactory ______.

9. Perform standby mode zero feet check IAW para 4-24 of TO extract.

   a. Standby, Zero Feet Check - Satisfactory ______
   Unsatisfactory ______

10. Perform reset mode zero feet check IAW para 4-25 of TO extract.

   a. Reset Zero Feet Check - Satisfactory ______
   Unsatisfactory ______

11. Perform standby functional check of altimeter IAW para 4-38 and table 4-3 of TO extract.

   a. Standby Functional Check - Satisfactory ______
   Unsatisfactory ______

12. Perform reset functional check of altimeter IAW para 4-38 and table 4-3 of TO extract.

   a. Reset Functional Check - Satisfactory ______
   Unsatisfactory ______

13. Perform electrical tests IAW instructions in para 4-40 of TO extract.

Note: Read Caution.

a. Electrical Tests - Satisfactory ______
Unsatisfactory ______

14. Perform AC power loss IAW para 4-42a, b, c, and d of TO extract.

a. AC Power Loss - Satisfactory ______
Unsatisfactory ______

15. Perform steps in para 4-43 of TO extract.

a. Satisfactory ______. Unsatisfactory ______.

16. Perform failure detection test IAW para 4-45 of TO extract.

a. Failure Detection Test - Satisfactory ______
Unsatisfactory ______

17. Perform altitude deviation test IAW para 4-47 of TO extract.

a. Satisfactory ______. Unsatisfactory ______.

18. Perform lighting test IAW para 4-49 of TO extract.

a. Satisfactory ______. Unsatisfactory ______.

19. Perform combined scale error and friction tests IAW para 4-51 and 4-52 and table 4-5 of TO extract.

Note: Read NOTE.

a. Satisfactory ______. Unsatisfactory ______.

20. Perform test set shutdown procedures IAW para 4-55 of TO extract.

a. __________

21. Perform test shutdown procedures IAW para 4-56 of TO extract.

a. __________

22. Secure test equipment IAW para 4-57 of TO extract.

a. __________

SECTION IV

CHECK LIST ELEMENTS

4-1. FIELD (INTERMEDIATE) REQUIREMENTS.

4-2. TEST SETS. The TTU-229/E and TTU-205B/E test sets, specified in paragraph 2-3, can be set up and operated on a minimum of bench space by one man.

4-3. SKILL LEVEL. The skill level and title recommended to perform the bench check of the altimeter is:

Air Force - AFSC 42250/32551 Instrument Repairman.

Navy - Aviation Electrician Mate, Code NEC 7105.

4-4. POWER. The power requirements for each test set are 115 Vac ± 5 Vac, single phase, 400 Hz ± 20 amperes maximum.

4-5. TEST ENVIRONMENT.

4-6. The test area should be clean and provide ready access to necessary power sources and test equipment. The tests are to be conducted under room ambient conditions.

4-7. Only common hand tools are required in addition to the test equipment specified in paragraph 2-3.

NOTE

Any altimeter that fails to meet either the minimum performance or visual inspection requirements, specified herein, shall be considered unacceptable. No repair is authorized at Field (Intermediate) level.

4-8. VISUAL INSPECTION.

4-9. Before connecting to the test sets, the altimeter shall be inspected for the following.

a. Damage to altimeter case, barometric scale zero setting knob, control switch, or electrical connector.

b. Distorted or corroded pins in electrical connector.

c. Foreign material in electrical connector or static port.

d. Defective or missing filter screen.

e. Cracked bezel.

f. Abrasion marks on lens.

4-10. TEST SET PREPARATION.

WARNING

Failure to release the pressure relief valve on Test Set TTU-229/E before removing the carrying case lid may cause possible damage to the Test Set and injury to personnel as a result of pressure differential. Operator should wear ear plugs when operating Test Set TTU-205B/E. Acoustical noise level of set can impair hearing.

NOTE

Test Sets TTU-229/E and TTU-205B/E have the capability to test a maximum of two altimeters simultaneously.

4-11. TEST SET TTU-205B/E. The accessories stowed within the carrying case lid of the test set, used for bench check of the altimeter, are one (1) each:

a. Fitting, part number MS33657-E-6.

b. P_s hose assembly, part number AN6270-6-240.

c. Power cable assembly, part number 610722-1, manufactured by Garret Corporation (72599).

CAUTION

Ensure that the POWER switch of the test set is in the OFF position before connecting accessories.

4-12. Make the following connections. (See figure 4-1.)

a. Attach fitting to the static port of altimeter undergoing test.

b. Connect P_s hose assembly to test set and altimeter undergoing test.

c. Connect power cable assembly to test set, then to external power source. (See paragraph 4-4.)

CAUTION

Before making any connection changes to the test set with power on, see paragraphs 4-53 through 4-56.

NOTE

Blanking plugs must remain on all test set connectors not being used during bench check of altimeter.

4-13. TEST SET TTU-229/E. Before unlatching the carrying case lid of the test set, press red button on side of case to release pressure relief valve.

4-14. The accessories stowed within the carrying case lid of the test set, used for bench check of the altimeter, are one (1) each:

a. Cable assembly, part number 17960010110, manufactured by Kollsman Instrument Corporation (89944).

b. Power cable assembly, part number 17960010070, manufactured by Kollsman Instrument Corporation (89944).

NOTE

Ensure that the POWER switch of the test set is in the OFF position before connecting accessories.

1307

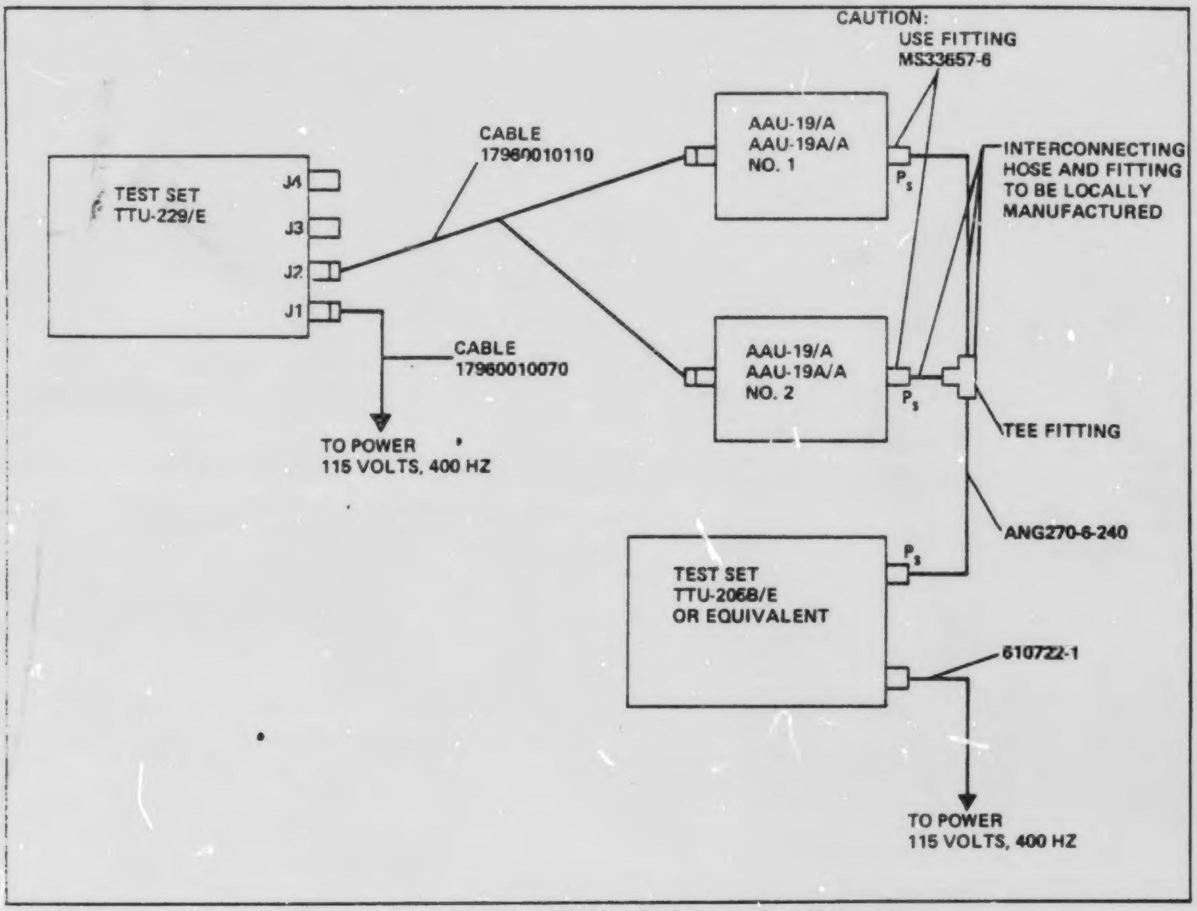

CAUTION:
USE FITTING
MS33657-6
CABLE
17960010110
TEST SET
TTU-229/E
J4
J3
J2
J1
CABLE
17960010070
TO POWER
115 VOLTS, 400 HZ
AAU-19/A
AAU-19A/A
NO. 1
P_s
AAU-19/A
AAU-19A/A
NO. 2
P_s
INTERCONNECTING
HOSE AND FITTING
TO BE LOCALLY
MANUFACTURED
TEE FITTING
ANG270-6-240
TEST SET
TTU-205B/E
OR EQUIVALENT
P_s
610722-1
TO POWER
115 VOLTS, 400 HZ

Figure 4-1. Type AAU-19/A, AAU-19A/A Field (Intermediate) Maintenance (Bench Check) Test Set Up

4-15. Make the following connections. (See figure 4-1.)

a. Connect cable assembly P_2 to electrical connector of altimeter undergoing test and receptacle J_2 of test set.

b. Connect power cable assembly P_1 to J_1 of test set then to external power source. (See paragraph 4-4.)

4-16. TEST SET SWITCH AND CONTROL SETTINGS.

4-17. TEST SET TTU-229/E. Set the switches and controls on the panel to the settings specified in table 4-1.

1346

Table 4-1. TTU-229/E Control Settings

TTU-229/E SWITCH/CONTROL	SETTING
POWER	OFF
INDUCED ERROR	ZERO
SYNCHRO SELECTOR	ALTIMETERS
SYNCHRO RESET	NORMAL
LIGHTING	OFF
SERVO	NORMAL
VIBRATOR	DISABLE
COMPUTER	NORMAL
ENCODER SELECTOR	OFF
ENCODER LAMP TEST	NORMAL

4-18. TEST SET TTU-205B/E. Set the switches and controls on the panel to the settings specified in table 4-2.

Table 4-2. TTU-205B/E Control Settings

TTU-205B/E SWITCH/CONTROL	SETTING
POWER	OFF
P_S & P_T EQUALIZERS	CLOSED
MACH LIMIT	0.95
PRESSURE MODULATION:	
FREQUENCY	OFF
AMPLITUDE	0
ALTITUDE CONTROL	ZERO FEET (APPROX.)
ALTITUDE RATE	30 (Max CW)
ALTITUDE FINE ADJUST	CENTER OF TRAVEL
AIRSPEED CONTROL	60 KNOTS (Full CCW)
AIRSPEED RATE	250 KNOTS
AIRSPEED FINE ADJUST	CENTER OF TRAVEL

4-19. TURN ON AND PRELIMINARY TEST/SETTING INSTRUCTIONS.

4-20. TEST SET TTU-229/E TURN ON. Set POWER switch to ON position and VIBRATOR switch to ENABLE position. The TEST SET, PILOT, CO-PILOT lamps shall illuminate.

4-21. TEST SET TTU-205B/E TURN ON. Set POWER switch to ON position.

4-22. Adjust altimeter barometric scale zero setting knob to indicate a reading of 29.92 inches of mercury on the barometric readout counter.

NOTE

Adjustment of barometric scale zero setting knob for test purposes shall always be made by approaching the setting in an increasing direction. Rotate the knob in a clockwise direction until the desired barometric counter readout is indicated. When necessary, the knob shall first be rotated in a counterclockwise direction until the counter indication is lower than the required setting.

The time delays of the control switch operation on the Aerosonic 10180-A and Bendix 3252001-0101 altimeters differ from The Kollsman A4132210002 and A4132210003 altimeter as follows:

With electrical and pneumatic inputs connected to the altimeters, all of the altimeters can be energized by rotating the control switch to the RESET position. The STBY flag will be concealed and the vibrator will cease to operate almost instantly. The altimeter can then be de-energized by rotating the control switch to the STBY position. On the Aerosonic 10180-A and Bendix 3252001-0101 altimeters, the STBY flag will return to view and the vibrator will operate within one-half second. The Kollsman A4132210002 and A4132210003 altimeters differ in that the return of the flag and the vibrator operation take two to three seconds; therefore, the control switch must be held in the STBY position for a longer time. All altimeters should be considered acceptable even though they differ in this respect.

4-23. LEAK TEST. Set the ALTITUDE SLEW RATE control to 5,000 feet per minute. Set Test Set TTU-205B/E to approximately 40,000 feet altitude. Hold LEAK TEST switch on Test Set TTU-205B/E in ON position. The leak rate observed on the altimeter shall not exceed 100 feet during a one-minute interval. Release LEAK TEST switch and return Test Set TTU-205B/E to zero altitude.

NOTE

The "Altitude Rate" control should be set to 5,000 feet per minute prior to setting the "altitude control" to 40,000 feet.

4-24. Set ALTITUDE control switch on Test Set TTU-205B/E to zero feet altitude. Adjust altitude fine adjust for zero indication on the altitude counter. Set the ALTITUDE SLEW RATE control to 5000 feet per minute. The altimeter shall indicate zero ± 45 feet. The STBY flag shall be visible on dial face.

NOTE

For accurate altitude adjustments on the TTU-205B/E Tester, utilize the "altitude fine adjust" control knob.

4-25. Rotate the SYNCHRO RESET switch on Test Set TTU-229/E until SYNCHRO DISPLAY indicates a reading of zero feet. Set the altimeter RESET-STBY control switch to the RESET position. The STBY flag shall not be visible on face of dial. The altimeter shall indicate zero ± 30 feet.

NOTE

During slewing operation of the SYNCHRO DISPLAY on Test Set TTU-229/E, both the PILOT and CO-PILOT panel lamps extinguish and the altimeter reverts to the standby mode of operation.

4-26. BAROMETRIC AND ELECTRICAL ZERO SETTING.

4-27. If scale errors in the pneumatic and/or electrical modes of operation exceed the allowable tolerances for paragraphs 4-24, 4-25 or 4-50, a barometric and/or electrical zero setting operation is required. The zeroset locking methods for each type of altimeter differ significantly; therefore, a separate procedure is provided for each manufacturer's instrument within type classification.

4-28. AAU-19/A ALTIMETER, AEROSONIC 10180-A. Perform barometric and electrical zero setting and verification operations in accordance with the following procedures. (See figure 4-2.)

4-29. BAROMETRIC ZERO SETTING (PNEUMATIC MODE).

a. Set altimeter RESET-STBY lever to STBY position.

b. Set Test Set TTU-205B/E to an altitude of zero feet.

c. With the knob (3) in the center (normal) position, rotate knob to set altimeter pointer to zero feet indication.

d. Loosen, but do not remove, barometric scale [illegible] adjustment locking screw (4). Locking plate (5) shall be loose and free from shaft engagement.

e. Withdraw knob (3) to its extended position and rotate until

1309

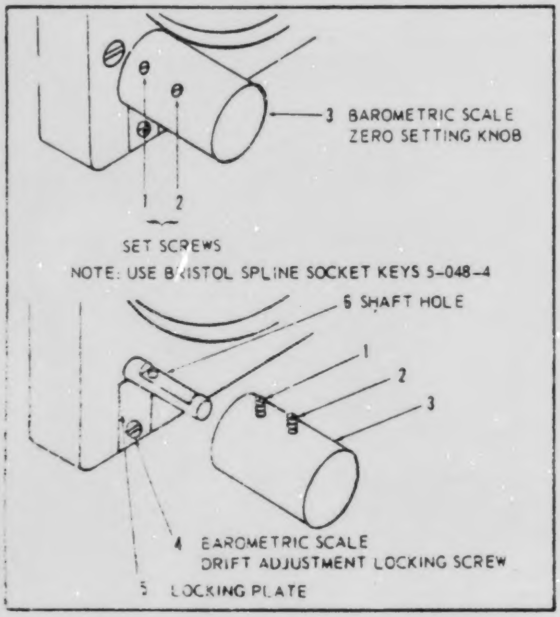

3 BAROMETRIC SCALE ZERO SETTING KNOB
1
2
SET SCREWS
NOTE: USE BRISTOL SPLINE SOCKET KEYS 5-048-4
6 SHAFT HOLE
1
2
3
4 BAROMETRIC SCALE DRIFT ADJUSTMENT LOCKING SCREW
5 LOCKING PLATE

Figure 4-2. Barometric and Electrical Zero Reset
(Aerosonic Type AAU-19/A)

altimeter barometric readout counter is reset to 29.92 inches of mercury and pointer indicates zero feet altitude.

d. To verify zeroing, return knob (3) to the center position. The pointer shall indicate zero ± 5 feet. If the pointer does not indicate zero feet within the specified tolerance, repeat step c.

4-30. ELECTRICAL ZERO SETTING.

a. Loosen setscrews (1) and (2) on knob (3) until knob can be moved out on shaft. Move out knob until hole (6) on shaft is visible. Tighten inner setscrew (1).

b. Set RESET-STBY control switch to RESET position.

c. Push knob (3) in and rotate until altimeter pointer indicates zero ± 5 feet.

NOTE

In the event that power on scale error data indicates that more accuracy can be obtained by offsetting the electrical setting, the pointer shall be adjusted to the desired offset instead of zero feet.

d. Return knob (3) to center position.

e. Set Test Set TTU-205B/E altitude control to zero feet. Verify zeroing by moving RESET-STBY control switch first to STBY then to RESET. The pointer shall continue to indicate zero ± 5 feet in either position. If not, repeat steps a. through e. as required.

f. When zeroing and verification procedures have been completed, position locking plate (5) in place and tighten locking screw (4). Loosen setscrew (1) and move knob (3) in until hole (6) on shaft is no longer visible. Be certain setscrew (1) is located in hole (6) on shaft. Setscrew (1) should be recessed more than setscrew (2) when properly located in hole.

g. Set RESET-STBY control switch to STBY position.

4-31. AAU-19/A ALTIMETER, KOLLSMAN A4132210002, A4132210003. Perform barometric and electrical zero setting and verification operations in accordance with the following procedures. (See figure 4-3.)

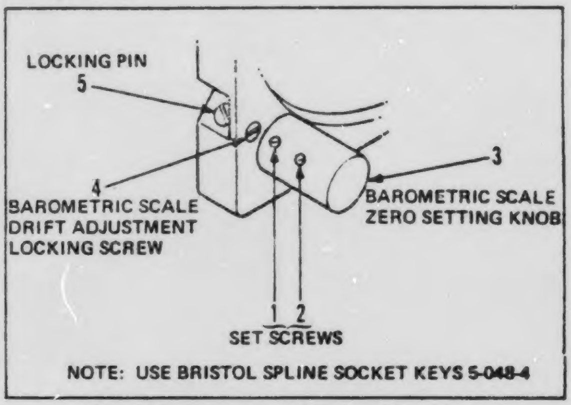

LOCKING PIN
5
4
BAROMETRIC SCALE DRIFT ADJUSTMENT LOCKING SCREW
3
BAROMETRIC SCALE ZERO SETTING KNOB
1
2
SET SCREWS
NOTE: USE BRISTOL SPLINE SOCKET KEYS 5-048-4

Figure 4-3. Barometric and Electrical Zero Reset
(Kollsman Type AAU-19/A)

4-32. BAROMETRIC ZERO SETTING (PNEUMATIC MODE).

a. Set Altimeter Reset-STBY Control Switch to STBY position.

b. Set Test Set TTU-205B/E to an altitude of zero feet.

c. With knob (3) in center (normal) position, rotate knob to set altimeter pointer to zero feet indication.

d. Loosen Barometric Scale Drift Adjustment Locking Screw (4) until head of screw is clear of recessed hole in altimeter bezel.

e. Push Locking screw (4) away from Barometric Scale Zero Setting Knob (3) until locking pin (5) has been lifted to its far up position.

f. Withdraw knob (3) to its extended position and rotate knob (3) until altimeter barometric readout counter is reset to 29.92 inches of mercury and altimeter pointer indicates zero feet altitude.

g. To verify re-zeroing return knob (3) to center position. The pointer shall still indicate zero ± 5 feet. If pointer does not indicate zero feet within specified tolerance, repeat steps c, f and g.

h. With knob (3) in its center (normal) position, reseat locking pin (5) back to its original position and tighten locking screw (4) insuring that it fits properly in recess of the bezel.

NOTE

In the event that standby scale error data indicates that more accuracy can be obtained by offsetting the pneumatic setting, the pointer shall be adjusted to the desired offset instead of zero feet. The unit must still meet all tolerances of table 4-5.

10
1348

4-33. ELECTRICAL ZERO SETTING.

a. Loosen setscrews (1) and (2) on knob (3) until knob can be moved out on shaft. Move knob out until hole on shaft is visible. Tighten setscrew (1).

b. Set Altimeter RESET-STBY control switch to RESET position.

c. With knob (3) in center (normal) position, rotate knob until altimeter barometric readout counter is reset to 29.92 inches of mercury.

d. Loose Barometric Scale Drift adjustment locking screw (4) until head of screw is clear of recessed hole in altimeter bezel.

e. Push locking screw (4) away from Barometric Scale Zero setting knob (3) until locking Pin (5) has been lifted to its far up position.

f. Push knob (3) in and rotate until altimeter pointer indicates zero ± 5 feet.

NOTE

In the event that power on scale error data indicates that more accuracy can be obtained by offsetting electrical zero setting, the pointer shall be adjusted to the desired offset instead of zero feet. The unit must still meet all tolerances of Table 4-5.

g. Return knob (3) to the center position carefully. Over travel past the center position could affect the pneumatic setting.

h. With knob (3) in its center (normal) position, reset locking Pin (5) back to its original position and tighten locking screw (4) insuring that it fits properly in recess of the bezel.

i. Set Test Set TTU-205 B/E altitude control to zero feet. Verify zeroing by moving altimeter RESET-STBY control switch first to STBY then to RESET. The pointer shall continue to indicate zero ± 5 feet in either position. If not, repeat paragraphs 4-32 and/or 4-33 as required.

j. When zeroing and verification procedures have been completed, loosen knob setscrew (1) and move knob in until hole on shaft is no longer visible. Tighten set screws (1) and (2) firmly. Be certain that set screw (1) is located in hole on shaft. Set Screw (1) should be recessed more than setscrew (2) when properly located in hole.

k. Set RESET-STBY control switch to STBY position.

4-34. AAU-19A/A ALTIMETER, BENDIX 3252001-0101. Perform barometric and electrical zero setting and verification operations in accordance with the following procedures (See figure 4-4.)

4-35. BAROMETRIC ZERO SETTING (PNEUMATIC MODE).

a. Set altimeter RESET-STBY control switch (1) to STBY position as shown in figure 4-4.

b. Set Test Set TTU-205B/E to an altitude of zero feet.

c. With knob (2) in center (normal) position, rotate knob to set altimeter barometric counter to 29.92 inches of mercury.

d. Using a number one Phillips screwdriver loosen, but do not remove, locking screw (3) until the screw head is just clear of the front of the bezel (approximately four turns). Do not force the screw if resistance is felt. Shaft lock (4) will drop approximately flush with bottom of the bezel as shown in figure 4-4, allowing knob (2) to be pulled out.

CAUTION

Extend or depress knob (2) carefully, without forcing. If resistance to the motion is felt, rotate the knob slightly until gear teeth are properly meshed.

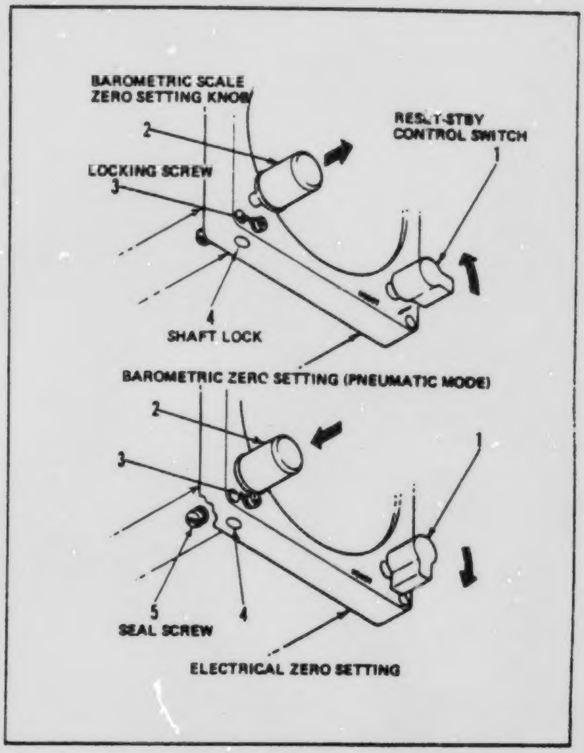

BAROMETRIC SCALE ZERO SETTING KNOB
2
RESET-STBY CONTROL SWITCH
1
LOCKING SCREW
3
4
SHAFT LOCK
BAROMETRIC ZERO SETTING (PNEUMATIC MODE)
2
3
1
5
SEAL SCREW
4
ELECTRICAL ZERO SETTING

Figure 4-4. Barometric and Electrical Zero Reset (Bendix Type AAU-19A/A)

e. Withdraw knob (2) to its extended position and rotate until altimeter pointer indicates zero feet. (Always approach the desired zero setting by rotating knob in a clockwise direction.)

f. To verify re-zeroing, return knob to center (normal) position. The pointer shall indicate zero ± 5 feet while the barometric counter indicates 29.92 inches of mercury. Repeat steps e and f if the pointer does not indicate zero feet within the specified tolerance.

NOTE

In the event that stand-by scale error data indicates that more accuracy can be obtained by offsetting the pneumatic setting, the pointer shall be adjusted to the desired offset instead of zero feet. The unit must still meet all tolerances of Table 4-5.

g. When zeroing and verification procedures have been completed, press shaft lock (4) back into altimeter housing to original position, and tighten backing screw (3).

4-36. ELECTRICAL ZERO SETTING.

a. Set RESET-STBY control switch (1) to RESET position as shown in figure 4-4.

b. Loosen, but do not remove, seal screw (5) approximately two and one-half turns. Using a Number One Phillips Screwdriver, loosen, but do not remove, locking screw (3) until head is clear of the front of bezel (approximately four turns). Shaft Lock (4) will drop flush with bottom of bezel as shown in figure 4-4 allowing knob (2) to be pushed in.

CAUTION

Extend or depress knob (2) carefully without forcing. If resistance to the motion is felt, rotate the knob slight' until gear teeth are properly meshed.

c. Push knob (2) in and rotate until altimeter pointer indicates zero ±5 feet. (Always approach the desired zero setting by rotating knob in a clockwise direction.)

1311

NOTE

In the event that power on scale error indicates that more accuracy can be obtained by offsetting electrical zero setting, the pointer shall be adjusted to the desired offset instead of zero feet.

d. Return knob (2) to center position.

e. Set Test Set TTU-205B/E altitude control to zero feet. Verify zeroing by moving RESET-STBY control switch (1) first to STBY then to RESET. The pointer shall continue to indicate zero ± 5 feet in either position. If not, repeat procedures given in steps a. through d. as required.

f. When zeroing and verification procedures have been completed, tighten seal screw (5). Press shaft lock (4) back into altimeter housing to original position and tighten locking screw (3).

g. Set RESET-STBY control switch (1) to STBY position.

4-37. FUNCTIONAL TESTS.

4-38. ZERO SETTING SCALE. With the altimeter in the STBY mode, and Test Set TTU-205B/E off and EQUALIZER open, rotate barometric scale zero setting knob (3) figures 4-2 and 4-3 or (2) figure 4-4, from 28.10 to 31.00 and check for smoothness of movement. Set knob at 28.10 and record altitude display reading. Change setting to 29.50, 29.92, 30.50, and 31.00 and record altitude display reading at each of these upscale settings. The difference in reading between settings shall be within the ranges specified in table 4-3. Change the barometric setting back to 30.50, 29.92, and 29.50, respectively, and record display reading at each setting. The readings taken at these downscale settings shall indicate within ± 30 feet of the readings taken at the same points on the upscale settings. The test shall be performed with the altimeter in the RESET mode. Prior to rotating the control switch to RESET, rotate the SYNCHRO RESET switch to slew the SYNCHRO DISPLAY to local field elevation. Upon completion of test, return altimeter to STBY mode.

Table 4-3. Zero Setting Scale Functional Test

BAROMETRIC SETTINGS	DIFFERENCE RANGE (in feet)
From 28.10 to 29.92	Between 1690 and 1760
From 29.50 to 29.92	Between 360 and 425
From 29.92 to 30.50	Between 500 and 570
From 29.92 to 31.00	Between 950 and 1020

4-39. ELECTRICAL TESTS.

CAUTION

Prior to applying power to test set TTU-205B/E, set the switches and controls on the panel to the settings specified in table 4-2. Return altitude rate to 5,000 feet after the test set stabilizes.

4-40. RESET-STBY CONTROL SWITCH, FLAG, AND VIBRATOR PERFORMANCE. Set barometric readout counter to 29.92 inches of mercury. On Test Set TTU-205B/E, close equalizer valves, turn Test Set to ON, adjust Test Set to produce an altimeter indication of approximately 500 feet. Slew Test Set TTU-229/E SYNCHRO DISPLAY until zero feet is indicated. Note that altimeter STBY flag is visible, vibrator is operating, and indicator shows approximately 500 feet. Set the RESET-STBY control switch to the RESET position. Note that altimeter STBY flag is concealed, vibrator operation ceases, and indicator shows zero ± 30 feet. Set RESET-STBY control switch to STBY position. Note that altimeter reverts to pneumatic mode, STBY flag is visible, vibrator is operating, and indicator shows approximately 500 feet.

4-41. AC POWER LOSS TEST.

4-42. Set the altimeter RESET - STBY control switch to RESET position. The altimeter pointer shall indicate zero ± 30 feet, the STBY flag shall be concealed, and the vibrator shall not be operating. Rotate the SYNCHRO RESET switch on Test Set TTU-229/E in either direction, in SLOW position, to slew the SYNCHRO DISPLAY. During the slewing operation observe that the following occurs.

a. Test Set TTU-229/E PILOT and CO-PILOT panel lamps extinguish.

b. The altimeter pointer indicates approximately 500 feet.

c. The STBY flag is visible.

d. The vibrator is operating.

4-43. Rotate Test Set TTU-229/E SYNCHRO RESET switch to NORMAL position and observe that the PILOT and CO-PILOT panel lamps illuminate. Hold Test Set TTU-229/E SERVO switch in RESET position, then release it to NORMAL position. Observe that the altimeter reverts to electrical mode of operation.

4-44. FAILURE DETECTION TEST.

4-45. With the altimeter in the RESET Mode of operation and Test Set TTU-205B/E set to zero altitude, rotate Test Set TTU-229/E SYNCHRO RESET switch to slew the SYNCHRO DISPLAY to zero feet. During the slewing operation the altimeter will revert to the pneumatic mode of operation. When the SYNCHRO DISPLAY indicates zero feet, release the SYNCHRO RESET switch to NORMAL position then hold Test Set TTU-229/E SERVO switch in RESET position to return altimeter to electric mode of operation. Set the SERVO switch to DISABLE position. Slowly increase the pneumatic input until the STBY flag appears. Vibrator operation shall start without tapping the case. When the STBY flag appears, the AAU-19/A altimeter reading shall be between 400 and 1000 feet of the electrical input; the AAU-19A/A altimeter shall be between 100 and 300 feet of the electrical input. After test is completed, rotate Test Set TTU-229/E SERVO switch to NORMAL position.

4-46. ALTITUDE DEVIATION TEST.

4-47. With the altimeter set in STBY mode, adjust Test Set TTU-205B/E pneumatic input until altimeter indicates 2000 feet. Place Test Set 229/E SYNCHRO SELECTOR in SELF TEST position and INDUCED ERROR control to 2000 feet. Set altimeter RESET-STBY control switch to RESET position. Record the altimeter scale error at 2000 feet induced error. Rotate Test Set TTU-229/E INDUCED ERROR control to each of the values listed in table 4-4. Errors shall be within tolerances specified. Induced error is defined as the difference, in feet, between pneumatic and electrical input.

Table 4-4. Altitude Deviation

PNEUMATIC INPUT (feet)	INDUCED ERROR SETTING (feet)	ALTIMETER INDICATION	TOL. (± feet)
2000	+ 2000	2000	30
2000	+ 3000	3000	40
2000	+ 1000	1000	40

1350

NOTE

At the completion of this test, rotate Test Set TTU-229/E INDUCED ERROR to 200 feet, set altimeter to STBY, rotate TEST SET TTU-229/E SYNCHRO SELECTOR control to ALTIMETER, and INDUCED ERROR control to zero. Return Test Set 205B/E to zero altitude.

4-48. LIGHTING TEST.

4-49. Set RED-OFF-WHITE switch of TEST SET TTU-229/E to the applicable colo and observe that the altimeter display illuminates.

4-50. COMBINED SCALE ERROR/FRICTION TEST.

4-51. SCALE ERROR TEST. The altimeter shall be subjected to the test points specified in table 4-5 for both the pneumatic and electrical mode of operation. The altimeter, while in the pneumatic (STBY) mode, shall be brought to the desired test pressure and the error determined. This error shall be recorded as the Standby Scale Error and shall be within the tolerance specific l in table 4-5. At the required RESET mode test points specified in table 4-5, the altimeter pressure input shall be set to the nominal test point pressure, and Test Set TTU-229/E SYNCHRO DISPLAY control set to the corresponding altitude setting. Errors shall be within tolerances specified in table 4-5.

NOTE

The Altimeter shall be observed for the presence of spurious pointer motion at the required RESET mode test points specified in Table 4-5. At each test point, the test set ALTITUDE contol shall be adjusted so that the altimeter indication is not in the counter transfer area. The permissible pointer motion shall be no greater than 0.080 inch (10 feet).

The Altimeter shall be reset each time Test Set TTU-229/E SYNCHRO DISPLAY has been slewed to a different test point, and reverted to STBY mode before the pressure is changed.

4-52. STOP AND JUMP FRICHTION TEST. The altimeter shall be tested for stop and jump friction at test poins specified in table 4-5. With Test Set TTU-299/E VIBRATOR switch set to the ENABLE position, the altimeter shall be subjected to a constant rate of decreasing altitude equivalent to the rates indicated. The change in reading of the pointer at the test points, due to its stopping and jumping while the counter is turning, shall be recorded as friction and shall not exceed the tolerances specified in table 4-5.

4-53. TEST SET SHUTDOWN PROCEDURES.

4-54. TEST SET TTU-205B/E. The procedure of paraph 4-55 shall be followed whenever one of the following conditions occur:

a. Any pneumatic connection is to be changed.
b. Prior to switching OFF at completion of tests.
c. Immediately following a power interruption.
d. Immediately following an abnormal pressure condition as indicated by any of the three red lamps.

4-55. Test Set TTU-205B/E shall be shutdown as follows:

a. Rotate AIRSPEED control fully counterclockwise (50 knots).
b. Rotate ALTITUDE control to local ambient altitude.
c. Check PRESSURE MODULULATION controls OFF, i.e., FREQUENCY control OFF, AMPLITUDE control 0. Allow pressure to stabilize until counters steady.
d. Open (counterclockwise) the P_s EQUALIZER and P_t EQUALIZER controls. Allow pressure to run down and stabilize at ambient as indicated by the counters.

NOTE

The counters require power for their operation. If power cannot be maintained on the test set, the counters will remain steady even as pressures bleed off.

e. Switch POWER OFF.

4-56. TEST SET TTU-229/E. Secure the test set by setting the switches and controls to the positions given in table 4-1.

4-57. Disconnect all hoses and cables from the altimeter and test sets and return to stowage unless required for further operation.

1314

Table 4-5. Scale Error and Friction Test

Altitude Test Points (feet)	Direction	Rate of Altitude Change (feet per minute)	Test Set TTU-229/E Vibrator Switch	Altimeter Mode of Operation	Friction Tolerance Stop and Jump Operational (± feet)	Scale error Tolerance	
						Power On (± feet)	Stby (± feet)
0	Upscale from -1000 feet	3-5K	Enable	Stby and Reset Mode	-	±30	±45
500	Upscale	3-5K	Enable	Stby and Reset Mode	-	30	50
1,000	Upscale	3-5K	Enable	Stby and Reset Mode	-	30	50
2,000	Upscale	3-5K	Enable	Stby and Reset Mode	-	30	60
20,000	Upscale	3-5K	Enable	Stby	-	-	195
40,000	Upscale	3-5K	Enable	Stby	-	-	345
62,000	Downscale from 62,000 to 60,000						
60,000	Downscale	3-5K	Enable	Stby	-	-	1200
50,000	Downscale	3000	Enable	Stby	100	-	-
40,000	Downscale	3-5K	Enable	Stby	-	-	345
30,000	Downscale	3-5K	Enable	Stby	-	-	270
20	Downscale	3000	Enable	Stby	50	-	-
15,000	Downscale	3-5K	Enable	Stby	-	-	155
10,000	Downscale	3-5K	Enable	Stby and Reset Mode	-	30	120
6,000	Downscale	3-5K	Enable	Stby and Reset Mode	-	30	90
5,000	Downscale	500	Enable	Stby	50	-	-
4,000	Downscale	3-5K	Enable	Stby and Reset Mode	-	30	75
2,000	Downscale	3-5K	Enable	Stby and Reset Mode	-	30	60
1,000	Downscale	500	Enable	Stby	50	-	-
500	Downscale	3-5K	Enable	Stby and Reset Mode	-	30	50
0	Downscale	3-5K	Enable	Stby and Reset Mode	-	30	45

1353

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-HO-303
3 February 1975

PITOT PRESSURE AND PITOT-STATIC CONTROL PANEL AND OPERATING INSTRUCTIONS

This handout is designed to be used in conjunction with programmed text 3ABR32531-PT-303, Pressure Temperature Test Set TTU-205/E and Automatic Altitude Reporting Equipment (AIMS). The information is essential for proper use of the pitot pressure and pitot-static control panel.

1. Purpose:

a. Provides a controlled input of pitot and/or static pressure(s) to the AIMS Altimetry System or AIMS Computer.

b. Used to leak test the above system or to provide the system with inputs of airspeed and/or altitude simulations.

c. Used as a substitute for the TTU-205/E.

2. Operational characteristics (refer to figure 1):

a. Almost identical to the MB-1 Field Tester as far as the operation is concerned.

b. The only exception is that the pitot and static pressures are supplied from an external source and not from an internal source.

c. The amount of pitot pressure that is needed by a system is read in knots on the airspeed indicator located on the control panel.

d. The amount of static pressure that is needed by the using system is read in feet on the altimeter located on the control panel.

e. Control Knob functions:

(1) Pressure Source Valve: Used to apply a controlled amount of external pressure to the using system. The amount of pressure will be read on the airspeed indicator located on the control panel. After reaching the desired airspeed, the valve is closed.

(2) Pressure Vent: When open, releases pressure from the using system and the control panel.

OPR: TAS
DISTRIBUTION: X
TAS - 300; TTOC - 2

Designed for ATC Course Use. Do Not Use on the Job.

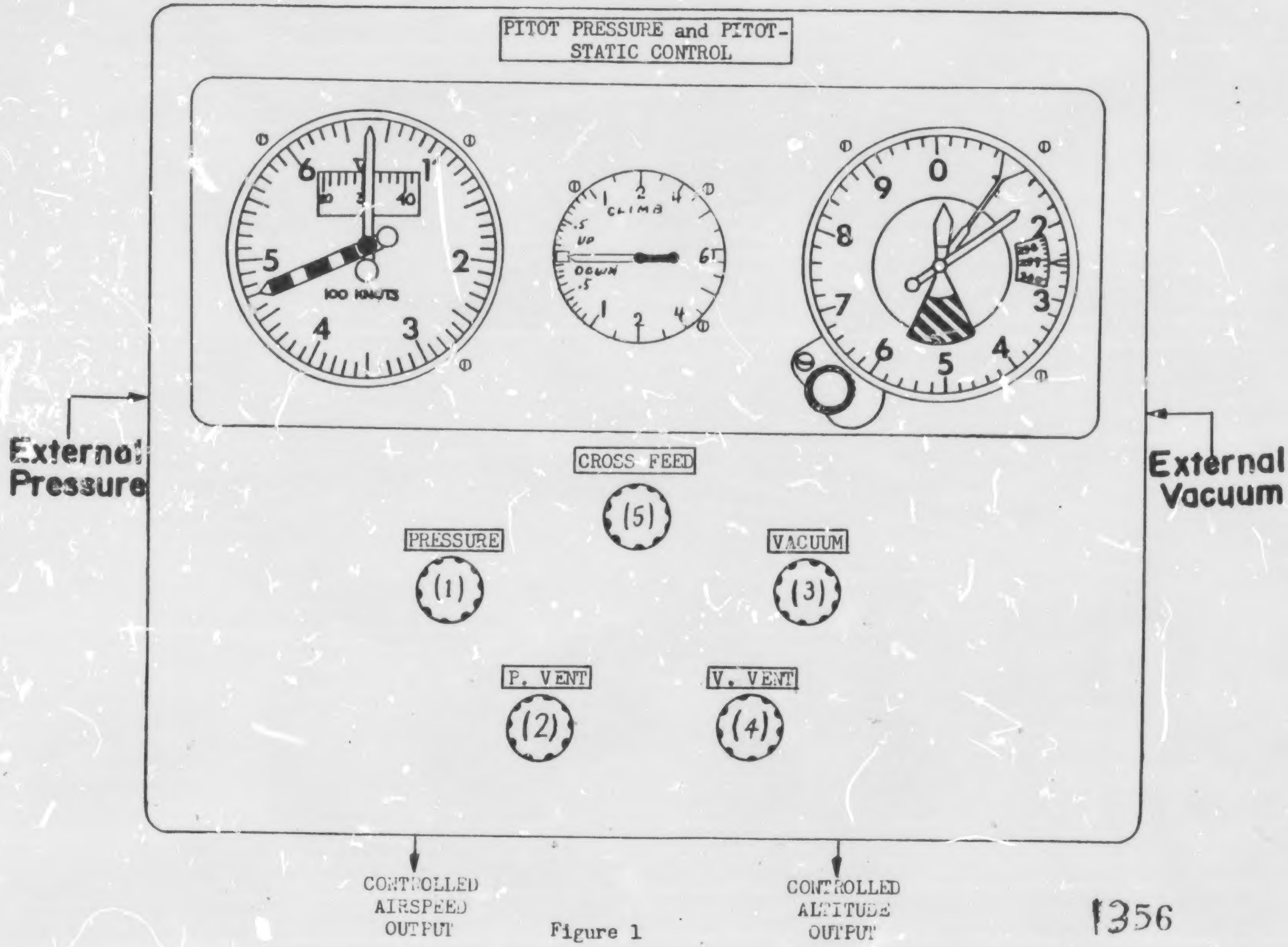

PITOT PRESSURE and PITOT-STATIC CONTROL
100 KNOTS
CLIMB
UP
DOWN
CROSS FEED
(5)
PRESSURE
(1)
VACUUM
(3)
P. VENT
(2)
V. VENT
(4)
External Pressure
External Vacuum
CONTROLLED AIRSPEED OUTPUT
CONTROLLED ALTITUDE OUTPUT

Figure 1

(3) Vacuum Source Valve: When open applies a vacuum source to the using system. The amount of vacuum required (static) will be read in feet on the altimeter located on the control panel.

(4) Vacuum Vent: When open, releases vacuum from the using system and the control panel.

(5) Cross Feed (refer to figure 2).

(a) Purpose: Used to obtain a low airspeed and high altitude reading at the same time.

(b) Operation: When the cross feed valve is opened, vacuum is applied to the pitot line. This decreases the differential pressure on the airspeed diaphragm. This decrease in differential pressure results in a lower airspeed indication. Since vacuum is applied to the pitot line, a decrease in altitude will result. Therefore, the vacuum source valve and the cross feed MUST be adjusted simultaneously to obtain the desired airspeed and altitude indications.

f. Remember, when applying any pressure/vacuum with the control panel, APPLY THEM SLOWLY. Pressure SURGES will damage the indicators and possibly the systems under test.

Caution: NEVER APPLY PITOT AND STATIC PRESSURE AT THE SAME TIME. NEVER VENT WITH THE CROSS FEED OPEN.

1318

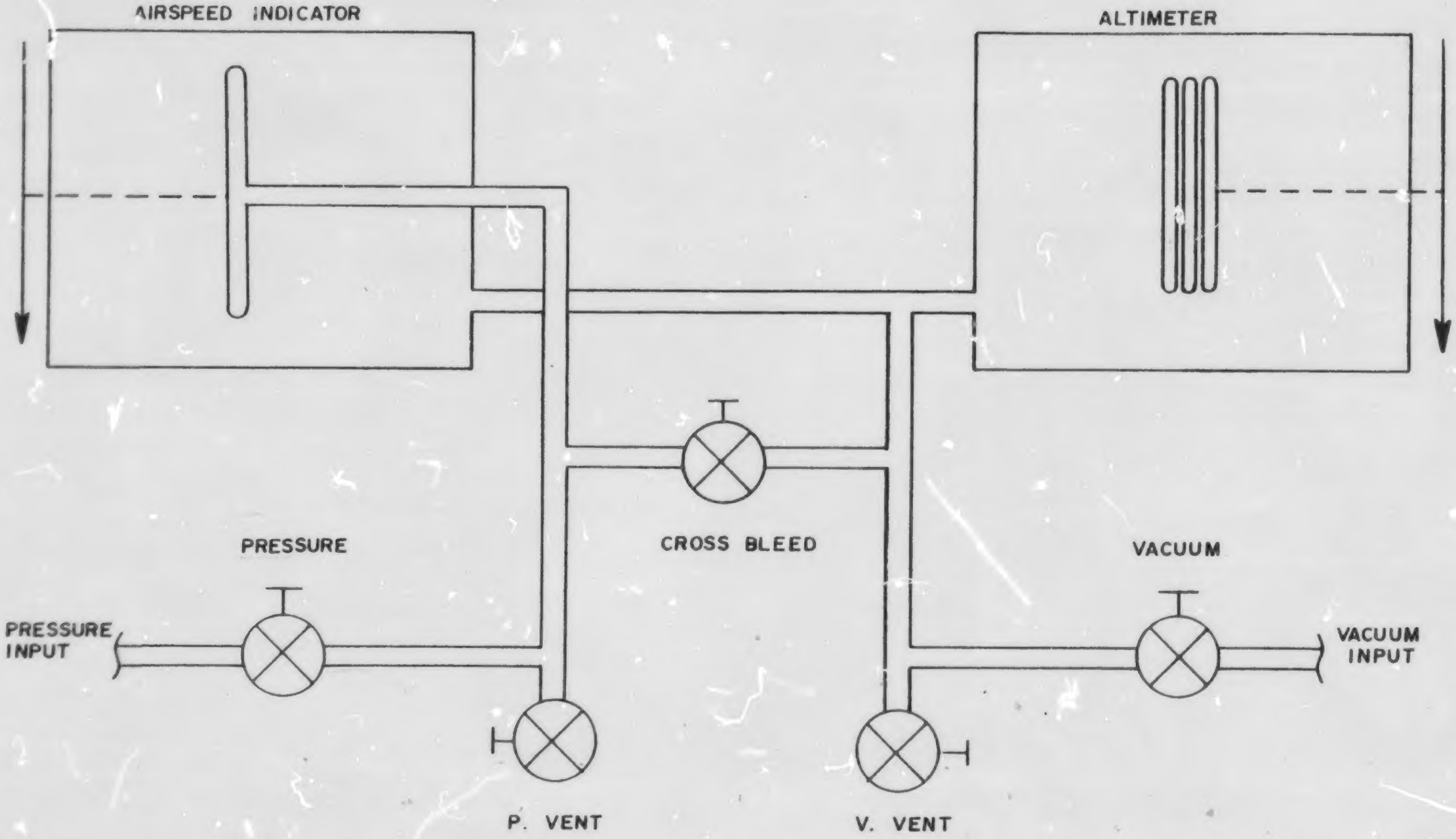

AIRSPEED INDICATOR
ALTIMETER
PRESSURE
CROSS BLEED
VACUUM
PRESSURE INPUT
VACUUM INPUT
P. VENT
V. VENT

Figure 2.

1358

1359

1319

PROGRAMMED TEXT

3ABR32531-PT-402A

Technical Training

Avionics Instrument System Specialist

OPERATION OF ACCELEROMETERS

7 February 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.
Do Not Use on the Job.

1360

1320

FOREWORD

This programmed text was prepared for use in the 3ABR32531, Avionics Instrument Systems Specialist Course. It was validated using 30 students from the course with 97% of the students achieving the objective as stated. The average time to complete the text was 35 minutes.

OBJECTIVE

1. Without references, identify facts pertaining to the purpose, operation, and/or characteristics of flight instruments with a minimum accuracy of 70%.

   a. Accelerometers.

INSTRUCTIONS

This programmed text presents information in small steps called frames. After reading the information in each frame, you are to select an answer by placing a checkmark (✓) by the correct response(s). Check your answers each time with the correct answer shown at the end of the following frame. If you made a correct response, go on to the next frame. If you make an incorrect response, reread the frame before going on to the next frame. Be sure that you understand the material presented in each frame before you continue. If you do not understand the text or have a question, raise your hand and your instructor will assist you.

Supersedes 3ABR32531-PT-302, 20 January 1975.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 200; TTVSA - 1

1361

The factors upon which the operation of the accelerometer is based are inertia and acceleration. By definition, inertia is the tendency of a body at rest to remain at rest. Also, a body in motion tends to remain in motion in a given direction, unless subjected to some outside force. Whenever an outside force acts on a body and overcomes inertia, there is acceleration. Acceleration is defined as a rate of change in velocity (speed or direction or both) per unit of time.

Check (✓) the true statement(s) below.

_____a. Operation of the accelerometer is dependent upon the factors of inertia and acceleration.

_____b. Inertia is a body in motion coming to a complete rest.

_____c. Inertia is the tendency of a body in motion to remain in motion.

_____d. Acceleration is defined as a change in inertia.

Frame 2

Acceleration increases as the applied force increases and decreases as the mass of the object increases. To illustrate this point, let's say that car A weighs 3,500 pounds and has a 235 horsepower engine. Car B weighs 3,500 pounds and has a 100 horsepower engine. We can conclude in this case, that with the increased horsepower (force) of car A, there is an increase in acceleration. On the other hand, increasing the mass (weight and size) of a car without increasing the engine power, results in a marked decrease in acceleration.

Check (✓) the correct statement(s) below.

_____a. Acceleration increases as mass increases.

_____b. Acceleration decreases as mass increases.

_____c. Acceleration increases as the applied force increases.

_____d. Acceleration decreases as the applied force increases.

_____e. If force is increased, acceleration will decrease.

Answers to frame 1: __✓__ a. __✓__ c.

Frame 3

Since acceleration is directly proportional to the force applied to an object, the amount of acceleration can be used as an indication of the amount of force applied. This is exactly what the accelerometer does. By measuring the amount of acceleration, the accelerometer indicates the amount of force applied to the aircraft and its crew (occupants).

Check (✓) the correct statement(s) below.

_____a. The accelerometer indicates the amount of inertia applied to the aircraft.

_____b. The accelerometer measures the amount of inertia.

_____c. The accelerometer cannot measure or indicate the amount of force applied to the aircraft and crew.

_____d. The accelerometer indicates the amount of force applied to the aircraft and crew.

Answers to frame 2: __✓__b. __✓__c.

Frame 4

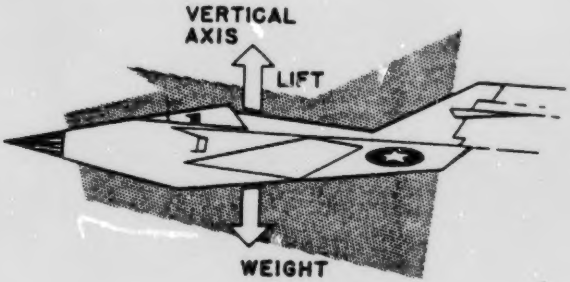
Match the definitions on the left to the terms on the right by listing the correct letters in the blank spaces.

1.	______	A change in velocity per unit of time.	a.	Inertia
2.	______	The tendency of a body at rest to remain at rest.	b.	Acceleration
3.	______	Indicates the amount of force applied to the aircraft and crew.	c.	Acceleration increases
4.	______	The applied force is increased.	d.	Acceleration decreases
5.	______	The applied force is decreased.	e.	Accelerometer

Answer to frame 3: ✓ d.

The force that the accelerometer indicates is the load acting along the vertical axis of the aircraft.

The accelerometer reacts only to forces that cause the aircraft to accelerate along the aircraft's vertical axis.



Check (✓) the correct answer(s).

The accelerometer indicates the:

_____a. force (load) acting along the horizontal axis of the aircraft.

_____b. lift acting along the horizontal axis.

_____c. forces that cause the aircraft to accelerate downward only.

_____d. force (load) acting along the vertical axis of the aircraft.

Answers to frame 4: 1. b 2. a 3. e 4. c 5. d

1326

Frame 6

The accelerometer indicates acceleration in "G" units. One "G" unit is the force exerted by the pull of gravity upon a body at rest. Acceleration due to gravity is 32 feet per second per second.

Check (✓) the correct answer(s).

1. The accelerometer indicates, in "G" units, the:

   _____a. force (load) acting along the horizontal axis of the aircraft.

   _____b. forces that cause the aircraft to accelerate upward only.

   _____c. force acting along the vertical axis of the aircraft.

   _____d. lift acting along the horizontal axis.

2. The accelerometer indicates:

   _____a. the horizontal lift in "G" units.

   _____b. inertia in "G" units.

   _____c. gravity.

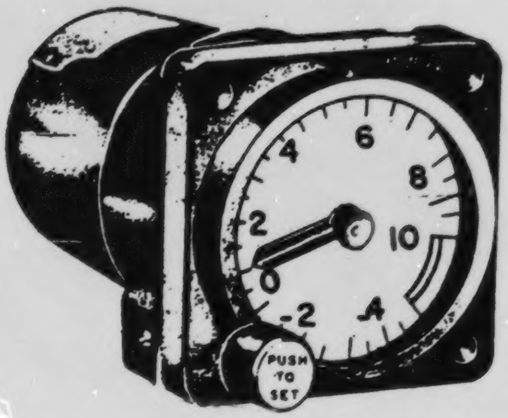
   _____d. acceleration in "G" units.

Answer to frame 5: __✓__d.

1367

The accelerometer compares the forces acting on the aircraft with the force of gravity. When the aircraft is at rest on the ground, the only force acting on it is the force of gravity; therefore, the accelerometer should indicate +1G. The accelerometer indicates +1G in flight when the lift of the wing is exactly equal to the weight of the aircraft (level flight).

The illustration below shows an accelerometer indicating +1G. This is what the accelerometer should indicate on the ground or in straight and level flight.



Check (✓) the correct statement(s) below.

_____a. The accelerometer should indicate 0 "G" on the ground.

_____b. The accelerometer should indicate +1"G" on the ground.

_____c. The accelerometer should indicate -1"G" in level flight.

_____d. The accelerometer should indicate 0 "G" in level flight.

_____e. The accelerometer should indicate +1"G" in level flight.

Answers to frame 6: 1.__✓__c. 2.__✓__d.

1328

Frame 8

The term plus one "G" (+1G) is the normal pull of gravity. The accelerometer indicates 1G only when the aircraft is on the ground or in level flight.

Check (✓) the correct answer(s) below.

An accelerometer indicates normal gravity (+1G) when the aircraft is:

_____a. in straight and level flight only.

_____b. climbing or diving.

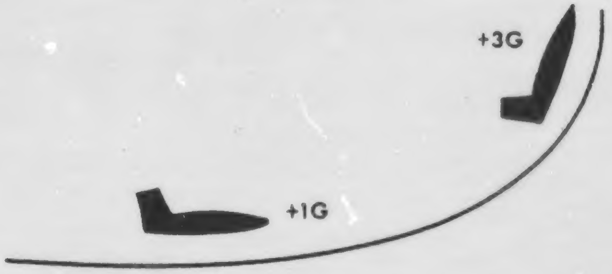
_____c. parked on the flight line or in straight and level flight.

_____d. parked on the flight line only.

1359

Answers to frame 7: __✓__b. __✓__e.

When the forces acting on the aircraft have the effect of increasing its weight (more than +1"G") such as during a pull-out from a dive, a tight turn, an inside loop, etc., positive "G"s will be indicated on the accelerometer. These forces apply additional stress on the aircraft structure.



Check (✓) the letter that identifies the correct answer.

Positive "G"s are indicated when:

_____a. the aircraft is in inverted, level flight.

_____b. the aircraft enters a dive.

_____c. the aircraft pulls out of a dive.

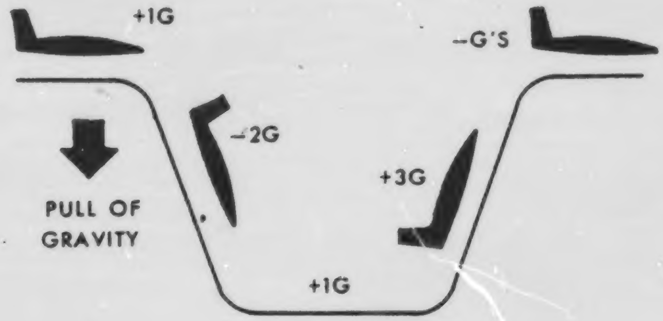
_____d. the aircraft levels out after a climb.

Answer to frame 8: __✓__c.

1330

Frame 10

When the forces acting on the aircraft have the effect of decreasing its wieght (less than +1"G") such as during leveling out after a climb, nosing down to start a dive, an outside loop, etc., negative "G"s will be indicated on the accelerometer. These forces also apply additional stress to the aircraft structure.



Check (✓) the letter that identifies the correct answer.

Negative "G"s are encountered when:

_____a. the aircraft climbs.

_____b. the aircraft pulls out of a dive.

_____c. nosing down to start a dive.

_____d. climbing upward.

1371

Answer to frame 9: __✓__c.

Put a T by statements below that are true and F by statements that are false.

1. _____ Inertia is the tendency of a body at rest to remain at rest.

2. _____ Acceleration is a change in velocity per unit of time.

3. _____ Acceleration increases as mass increases.

4. _____ Acceleration increases as the applied force increases.

5. _____ The accelerometer indicates the amount of inertia applied to the aircraft.

6. _____ The accelerometer indicates the amount of force applied to the aircraft and crew.

7. _____ The accelerometer indicates the force (load) acting along the vertical axis of the aircraft.

8. _____ The accelerometer indicates in "G" units.

9. _____ The accelerometer should indicate +1"G" on the ground or when the aircraft is flying straight and level.

10. _____ The normal pull of gravity is plus one "G."

11. _____ Positive "G"s have the effect of increasing weight, therefore; increasing stress on the aircraft.

12. _____ Negative "G"s have the effect of increasing stress on the aircraft during a steep turn.

13. _____ Negative "G"s have the effect of decreasing the weight placing additional stress on an aircraft when nosing down to begin a dive.

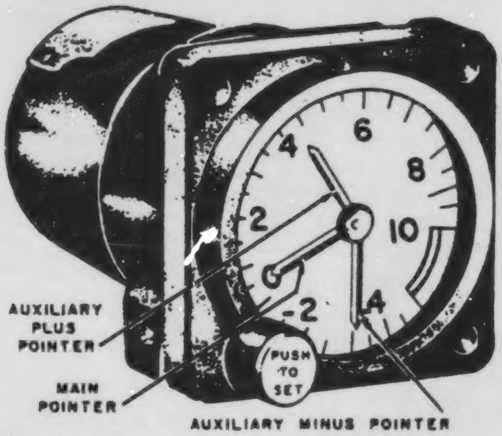
Answer to frame 10: __✓__ c.

1332

Frame 12

One type of accelerometer indicates both positive and negative acceleration. Positive acceleration causes plus reading and negative acceleration causes minus readings. An accelerometer that indicates positive and negative "G"s is the AF type B-6. The range of this instrument is from -5G to +10 G.

The type B-6 accelerometer has three indicating pointers. The main pointer gives a continuous indication of changes in acceleration as they occur. The two auxiliary pointers indicate the highest maximum plus and minus readings reached during any flight or maneuver.



Match the definitions on the left to the terms on the right by listing the correct letters in the blank spaces provided.

1. _____ Gives a continuous indication of changes in acceleration.

2. _____ Indicates the highest plus changes in acceleration.

3. _____ Indicates the highest negative changes in acceleration.

4. _____ Indicates the highest negative and positive changes in acceleration.

a. Auxiliary plus pointer

b. Auxiliary minus pointer

c. Auxiliary pointers

d. Main pointer

Answer to frame 11: below

Note: If you answered any of the statements incorrectly, go back to the pages indicated next to the correct answer. Return to this page only after you are sure you can answer all statements correctly.

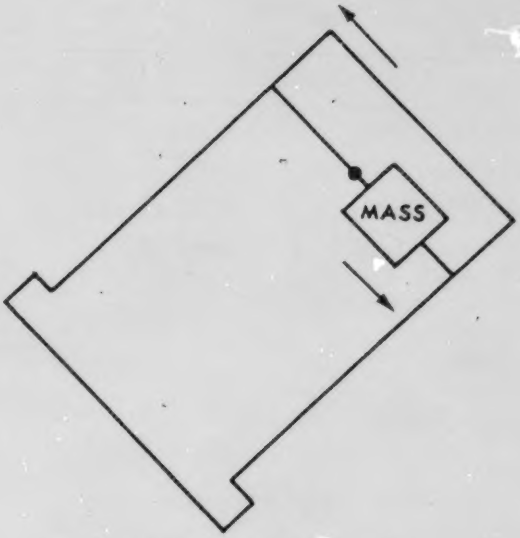
1. T (2) 2. T (2) 3. F (3) 4. T (3) 5. F (2-4)

6. T (4) 7. T (5) 8. T (5) 9. T (6) 10. T (7)

11. T (7) 12. F (8) 13. T (8)

The auxiliary plus and minus pointers are mounted on separate hollow shafts which turn with the main shaft. A ratchet and pawl assembly for each pointer limits the turning of these hollow shafts to one direction only. Thus, the auxiliary plus pointer will only move up, and the auxiliary negative pointer will only respond to negative accelerations.

When we speak of mass movement, we are only speaking of relative movement; that is, movement between the accelerometer (case) and the mass. When the aircraft goes into a dive, the mass will tend to remain fixed in space, while the accelerometer (case) will move downward. The net result of this action will be that the mass will move up the two mass guides. The diagram below indicates that an aircraft is climbing at an accelerated rate.

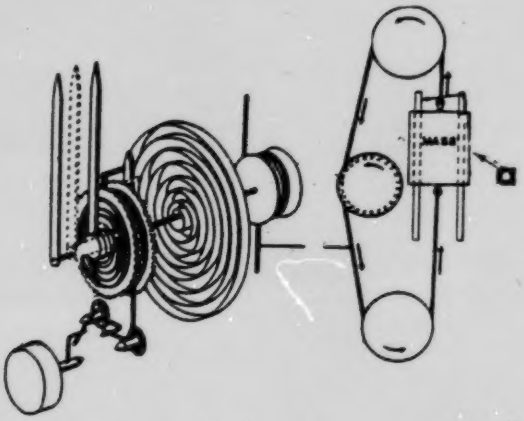


No Response Required

Answers to frame 12: 1. d 2. a 3. b 4. c

Frame 14

The sensitive element is a phosphor bronze weight called the mass. (The mass is designated "a" on the diagram.) The mass is mounted on a pair of guides (mass shafts) and moves up and down in response to changes in acceleration.



Check (✓) the letter that identifies the correct answer.

The sensitive element in the accelerometer:

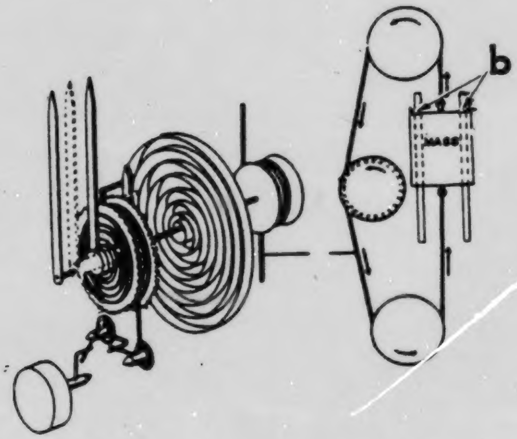
_____a. is the main pointer.

_____b. is the main spring.

_____c. is the mass.

_____d. are the mass guides.

During level flight, the position of the mass ("b" on the diagram) is about midway between the top and bottom of the mass guides.



Check (✓) the letter that identifies the correct answer.

When the aircraft is in level flight, the position of the mass is:

_____a. at the top of the mass guides.

_____b. about midway on the mass guides.

_____c. at the bottom of the mass guides.

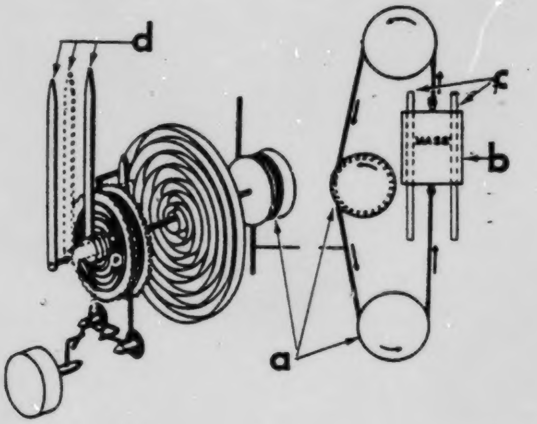
_____d. either at the top or bottom of the mass guides.

Answer to frame 14: __✓__c.

Frame 16

When the aircraft goes into a dive, the mass will move up the two mass guides and cause counterclockwise rotation of the pulley system. Two pointers of the assembly will move toward a minus "G" indication. Refer to the diagram and locate the pulleys (a), the mass (b), guides (c), and the pointer assembly (d).

Note: Only the main and negative pointers would move in a dive.



Check (✓) the letter that identifies the correct answer.

The main and negative pointer assembly will move toward a minus "G" indication when the aircraft:

_____a. accelerates away from the earth.

_____b. climbs.

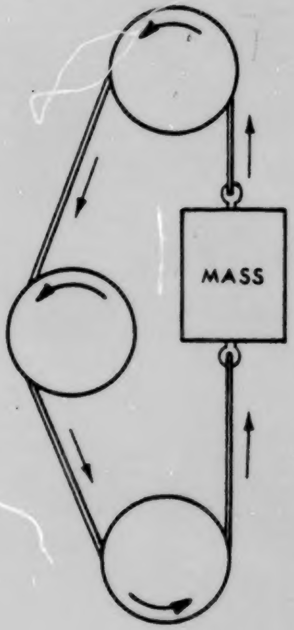
_____c. pulls out of a dive.

_____d. accelerates toward the earth.

Answer to frame 15: ✓ b.

When the aircraft goes into a climb, or pulls out of a dive, the mass will move down the guides and cause clockwise rotation of the pulley system. The pointer assembly will move toward a positive "G" indication.

Study the picture (right) and check the correct answer to the statement below.



The aircraft is:

_____a. accelerating away from the earth.

_____b. going into a climb, or pulling out of a dive.

_____c. going into a dive, or pulling out of a climb.

_____d. in level flight.

Answer to frame 16: __✓__d.

Frame 18

The string and pulley assembly transfers the movement of the mass to the main pointer shaft (e). The main pointer will move whenever the mass moves.

Check (✓) the letter that identifies the correct answer.

The purpose of the string and pulley assembly is to transfer movement of the:

_____a. main spring.

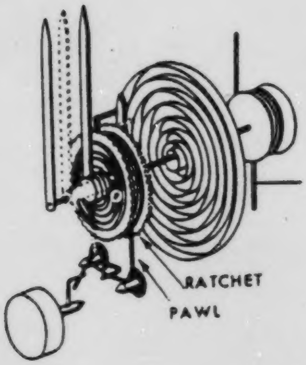
_____b. hair spring.

_____c. guides.

_____d. mass to the main pointer shaft.

Answer to frame 17: __✓__c.

The auxiliary plus and minus pointers are restricted to turning in one direction only. That is, the plus pointer will only move up and the negative pointer will only move down. A ratchet and pawl assembly (refer to picture below) for each pointer limits the turning in one direction.



Check (✓) the letter below that identifies the correct answer.

After the aircraft has performed a +3"G" maneuver, and returned to level flight, the main pointer should indicate +1"G," and the auxiliary positive pointer should indicate a:

_____a. +1"G"

_____b. +3"G"

_____c. 0"G"

_____d. +2"G"

Answer to frame 18: __✓__d.

1340

Frame 20

The auxiliary negative pointer will remain at the maximum negative reading obtained during flight. The auxiliary positive pointer will remain at the maximum positive reading obtained during flight.

The ratchet and pawl assembly will hold the auxiliary pointers at the maximum readings obtained during flight.

Check (✓) the letter that identifies the correct answer.

The unit that holds the auxiliary pointers at the maximum reading is the:

_____a. main spring.

_____b. hair spring and main spring.

_____c. mass and guides.

_____d. ratchet and pawl assembly.

1381

Answer to frame 19: __✓__b.

Pushing the reset knob located on the front of the instrument lifts the pawls from the ratchets, allowing the hair springs (attached to the ratchets) to pull the auxiliary pointers back to +1"G."

What two things happen when the reset knob is pushed?

_____a. The pawls are removed from the ratchets.

_____b. The hair springs are wound up and the pawls are lifted.

_____c. The pawls are lifted from the ratchet and the hair springs pull the auxiliary pointers back to +1"G."

_____d. The hair springs and main spring are wound up.

Answer to frame 20: __✓__d.

1342

Frame 22

A locking knob, located on the rear of the instrument case, locks the weight in place for shipping, handling and storage. This prevents damage to the mass and indicating mechanism. During installation, inspection and during an operational check of the accelerometer, be sure the mechanism is unlocked.

Note: The newer types of accelerometers (MA-1, etc.) will not have a locking knob.

Check (✓) the letter that identifies the correct answer.

The purpose of the locking knob (if indicator has one) is to:

_____a. lock the mass for flight.

_____b. unlock the mass only during a preflight inspection.

_____c. lock the mass for shipping and handling.

_____d. reset the main pointer.

1383

Answer to frame 21: __✓__c.

The accelerometer requires very little maintenance. However, an inspection check and a limited operational check, normally made by the pilot during the preflight inspection, can be performed.

Check (✓) the letter that identifies the correct answer.

What checks can be made on the accelerometer?

_____a. Functional and preflight checks.

_____b. Preflight and operational checks.

_____c. Operational and inspection checks.

_____d. Inspection and preflight checks.

Answer to frame 22: __✓__c.

1384

Frame 24

The inspection of the accelerometer will be a visual one. Checks will be made for cleanliness of cover glass; cover glass for cracks; range markings for proper limits, chips and discoloration: alignment of index mark; pointers set to +1"G" or within the listed tolerance; and security of mounting and lock knob (if instrument has one) for being unlocked.

Check (✓) the letter that identifies the correct answer.

The one thing that will NOT be checked during the inspection of the accelerometer is:

_____a. correct "G" range of instrument.

_____b. pointers set to a +1"G" indication.

_____c. range markings for proper limits.

_____d. security of mounting of the instrument.

Answer to frame 23: __✓__c.

Frame 25

The operational check of the accelerometer is a check to see if the indicator is functioning properly and within tolerance. This check consists of checking the indicator for alignment of all pointers at +1"G" or within tolerance, when push-to-set knob is pushed. Freedom of movement of push-to-set knob when it is pushed should also be checked.

Check (✓) the letter that identifies the correct answer.

During an operational check the accelerometer is checked for:

_____a. security of mounting.

_____b. auxiliary pointers moving to their maximum "G" indication.

_____c. proper functioning and operation within tolerances.

_____d. limits of range markings.

Answer to frame 24: __✓__a.

Note: If the instrument fails to operate properly it should be replaced with a serviceable one.

Note: Before proceeding to Section "B" (frame 26), ask your instructor for the examination covering Section "A."

Answer to frame 25: __✓__c.

1346

Flt Tng Device and Inst/Flt Cont Branch
Chanute AFB, Illinois

3ABR32531-WS-402
6 March 1978

INSPECTION AND OPERATIONAL CHECK OF THE ACCELEROMETER

ECTIVE

Given a workbook, test equipment and components, perform an inspection and operational check of flight instruments with a minimum of 100% accurate workbook responses.

EQUIPMENT

	Basis of Issue
Accelerometer Indicator	1/student

PROCEDURE

Visually inspect the accelerometer and make a checkmark (✓) in the satisfactory column under YES or NO in accordance with your findings.

Inspect for:	SATISFACTORY	
	YES	NO
1. Clean cover glass		
2. Cover glass intact		
3. Paint on dial for;	☒	☒
a. Cracks		
b. Discoloration		
4. Place locking knob on back of indicator to "UNLOCKED."	☒	☒
5. Security and proper mounting (aircraft only)	☒	☒
6. Check range marking decals for;	☒	☒
a. Discoloration, cracked or chipped		
b. Proper limits (aircraft only)	☒	☒
7. Check slippage mark		
8. Pointers set on +1 "G" (tolerance 0.1"G")		

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1387

1347

Perform an operational check of the accelerometer. Make a checkmark (✓) in the satisfactory column under YES or NO in accordance with your findings.

Note: If the indicator has one, the locking knob should be in the unlocked position.

Check for;

1. Holding the indicator upright and level the main pointer should read +1"G" (tolerance 0.1 "G").

SATISFACTORY	
YES	NO

2. Rotate the indicator 180° (upside down) and level, the main pointer should read -1 "G" (tolerance 0.1 "G").

SATISFACTORY	
YES	NO

3. Holding the indicator upright and level the auxiliary pointers should return to +1"G" when the Push-TO-Set knob is pushed.

SATISFACTORY	
YES	NO

Note: Be sure to lock the accelerometer prior to returning it to storage.

PROGRAMMED TEXT
3ABR32531-PT-303
3ABR32632B-PT-403

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

OPERATION OF FLIGHT DATA RECORDERS

16 January 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 69 AND 523, MAY 71. STANDARD COVERSHEET

FOREWORD

This programmed text has been prepared for use in the 3ABR32531, Avionics Instrument Systems Specialist Course and the 3ABR32632B, Integrated Avionic Systems Specialist Course.

OBJECTIVE

Without references, identify facts pertaining to the purpose, operation and/or characteristics of flight data recording systems with a minimum accuracy of 80%.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading the information in each frame you are asked to select an answer or make an entry that shows that you understand the information in that frame. After completion of the programmed text, you will be required to complete an appraisal designed to test your knowledge of the information contained herein. Read each frame in this programmed text carefully and be sure you understand each frame before proceeding to the next. DO NOT RUSH. If you do not understand any portion of this programmed text, ask your instructor for assistance.

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upersedes 3ABR32531-PT-303 and 3ABR326323-PT-403, 13 July 1977.
R: 3360 TCHTG
TRIBUTION: X
'60 TCHTG/TTGU-F - 200; TTVSA - 1

Frame 1

In recent years the Air Force has had an increase in the loss of aircraft due to structural failures. Costly losses such as these lower the mission readiness and stress the need for a system which will assure structural soundness. With this in mind, the Aircraft Structural Integrity Program (ASIP), as governed by AFR 80-13, was established.

The intent of ASIP is twofold; the purpose of the program is to establish aircraft structural integrity, structural criteria, and techniques of operational usage, while the scope of ASIP is to coordinate and provide guidelines for all structural activities for a given aircraft from design date to phase out.

Check (✓) the statements below for the correct answer.

1. The purpose of ASIP is to

_____a. establish aircraft structural integrity, criteria, and techniques of operational usage.

_____b. add more aircraft to the Air Force inventory.

_____c. monitor all aircraft communication.

_____d. improve existing aircraft performance.

2. The scope of ASIP is to

_____a. check the accuracy of flight data.

_____b. provide information of flight tests.

_____c. monitor flight data for short test periods on experimental aircraft.

_____d. coordinate and provide guidelines for structural activities for a given aircraft from design date to phase out.

Frame 2

To accomplish the objectives of ASIP, accurate, complete and timely flight information must be available for analysis. In order to gather this flight information, the Air Force has adopted the use of flight data recording systems. Because of the number of aircraft and locations involved, the flight data recorders will be kept operational by base level maintenance.

This PT will deal with two types of flight data recording systems that you may be required to maintain. The two systems discussed in this text are the VGH recording system, (Flight Data Recorder), which will be covered first, and the multichannel recording system (Airborne Signal Data Recorder), which will be covered in detail in the second part of the PT.

NO RESPONSE REQUIRED

Answers to Frame 1: 1. __✓__a. _____b. _____c. _____d.

2. _____a. _____b. _____c. __✓__d.

Frame 3

The VGH recording system (Flight Data Recorder) consists of the following three components:

1. **VGH recorder - processes inputs of Velocity, Gravity and Height.**

2. **Servo Accelerometer - senses gravity (vertical acceleration).**

3. **Tape Magazine - records inputs on a magnetic tape.**

As integral parts of the VGH recording system, these components will be discussed in more detail in the next several frames of this text.

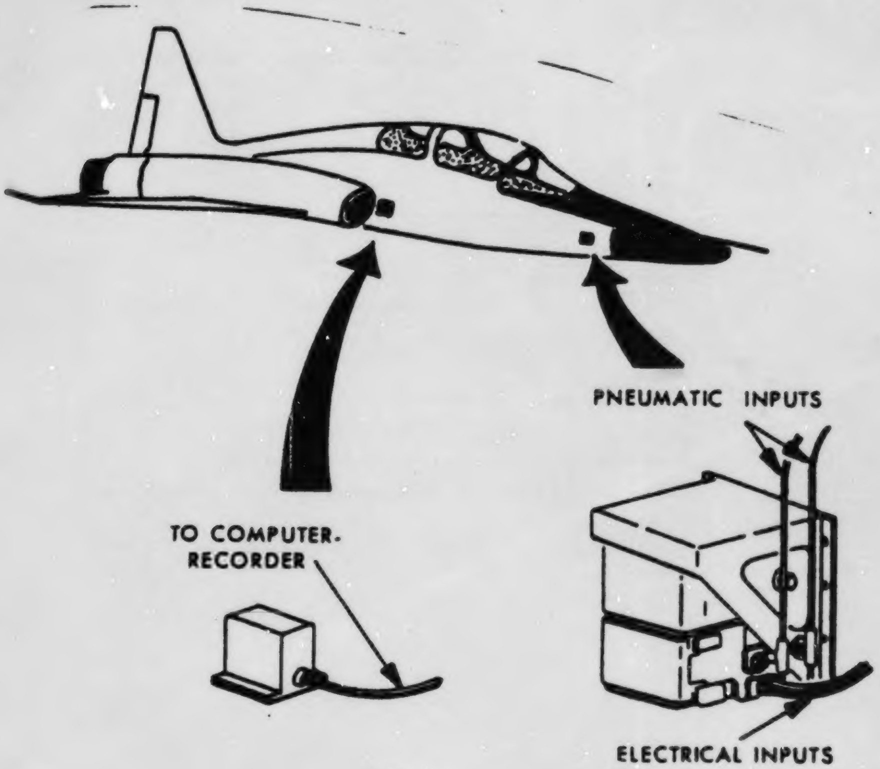


Figure 1.

Check (✓) the correct statement below.

What are the components of the VGH flight data recording system?

_____a. Accelerometer, recorder and tape magazine.

_____b. Accelerometer, computer and recorder.

_____c. Computer, recorder and tape magazine.

_____d. Computer, tape magazine and accelerometer.

1353

Frame 4

The VGH recorder (Flight Data Recorder) consists of a shock mounted chassis which contains a power module, two removable pressure transducers, and a removable computer module. The recorder unit receives inputs of indicated static pressure (psi) and total pressure (Pt) from the aircraft's pitot-static system. These inputs are applied to the transducers as shown in figure 2. The pneumatic inputs are converted to an electrical signal which is sent to the computer module. The servoaccelerometer supplies an input directly to the computer module in the form of an analog DC voltage. The computer module then processes and converts these inputs into binary number outputs and sends them to the tape magazine. The tape magazine receives these binary number inputs and records the processed data on a magnetic tape.

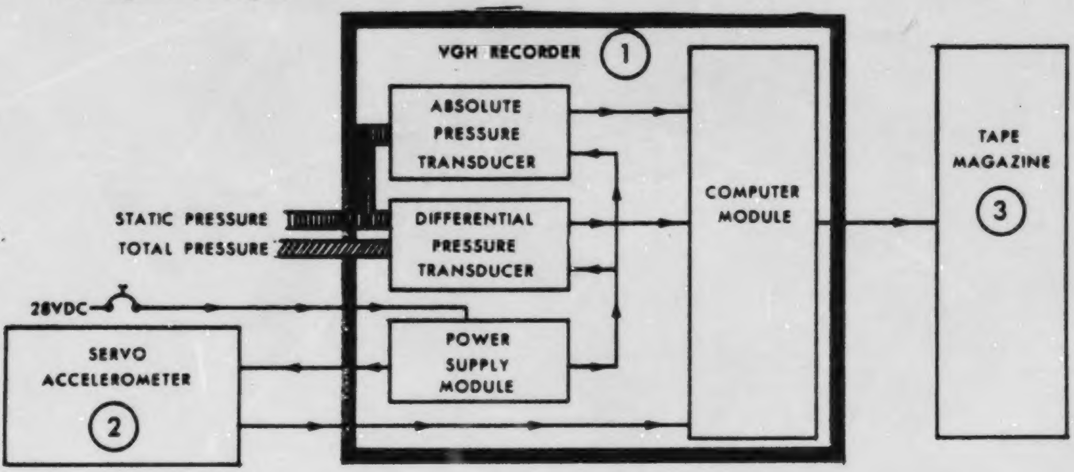

VGH RECORDER ①
ABSOLUTE PRESSURE TRANSDUCER
DIFFERENTIAL PRESSURE TRANSDUCER
POWER SUPPLY MODULE
COMPUTER MODULE
TAPE MAGAZINE ③
STATIC PRESSURE
TOTAL PRESSURE
28VDC
SERVO ACCELEROMETER ②

Figure 2.

Check (✓) the following statements which best answers the question.

What is the purpose of the VGH recorder?

_____a. To receive pneumatic and analog inputs and compute them into binary numbers.

_____b. To compute only inputs from the accelerometer into analog output.

_____c. To provide a feedback to the computer.

_____d. To energize and deenergize the servoaccelerometer when computing data.

Answers to Frame 3: ✓ a. _____b. _____c. _____d.

1394

Frame 5

The purpose of the servo accelerometer, located near the aircraft's center of gravity, is to sense the gravitational forces (G's) acting upon the aircraft.

The servo accelerometer will send a DC analog voltage proportional to the gravitational forces (G's) to the VGH recorder computer module. The computer module processes the DC analog voltage input and transmits a binary number output to the tape magazine for recording.

Check (✓) the correct statement below.

What is the purpose of the servo accelerometer?

_____a. To measure the aircraft's center of gravity.

_____b. To feed a DC analog voltage to the tape magazine.

_____c. Sense the gravitational forces acting upon the aircraft.

_____d. Sense the altitude of the aircraft above sea level.

Answer to Frame 4: __✓__a. _____b. _____c. _____d.

Frame 6

The tape magazine is a completely self-contained, hermetically sealed unit. The magazine receives binary data from the recorder unit and records this information on a magnetic tape.

The tape magazine has an indicator that shows the amount of tape remaining in hours. Its range is from 99 (full) to 00 (empty). As the tape reaches 00 indication, further tape movement is halted as the tape transport mechanism locks. The tape magazine is then removed and a fresh tape magazine installed in its place.

Check (✓) the best answer.

The tape magazine will do what?

_____a. Fly the aircraft in case of power failure.

_____b. Function as a self-contained tape recorder.

_____c. Function as a computer.

_____d. Function as a self-contained power supply.

Answer to Frame 5: _____a. _____b. __✓__c. _____d.

Frame 7

A data plate is mounted on the shell of the tape magazine to give information about the tape magazine installation such as dates, type of aircraft, squadron, etc. A view of a common data plate is shown in figure 3.

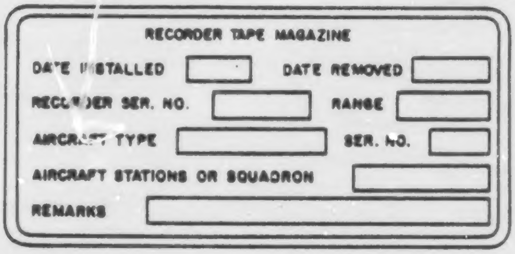

RECORDER TAPE MAGAZINE
DATE INSTALLED
DATE REMOVED
RECORDER SER. NO.
RANGE
AIRCRAFT TYPE
SER. NO.
AIRCRAFT STATIONS OR SQUADRON
REMARKS

Figure 3.

Check (✓) which of the following statements is true.

_____a. The tape magazine is self-contained and hermetically sealed.

_____b. The tape magazine has a tape remaining indicator that shows the remaining tape in feet and inches.

_____c. Tape magazine data is found on the data plate.

Answer to Frame 6: _____a. __✓__b. _____c. _____d.

1357

Frame 8

The recording system records the vertical acceleration (G) peaks sensed at the aircraft's center of gravity during flight. As G peaks are recorded, the indicated airspeed (V), altitude (H) and elapsed time for each is also recorded on the same tape.

The magnetic tape is contained in a quick-detachable magazine which is removed for playback on the ground. A playback of the tape indicates: (1) the G peaks sensed during flight, (2) the indicated airspeed and altitude of the aircraft when each G peak occurred, (3) the elapsed time each happened.

Check (✓) the statement which answers the question best.

1. What is the purpose of the tape magazine?

_____a. To record all flight data.

_____b. To record G peaks along with altitude, indicated airspeed and elapsed time.

_____c. To record only G peaks, indicated airspeed, and correct GMT time in hours and minutes.

_____d. To record G peaks, airspeed, and altitude of takeoffs and landings.

2. What is the purpose of the flight data recorder systems?

_____a. To record operational flight data.

_____b. To keep up on pilot's abilities.

_____c. To maintain shop records.

_____d. To assist pilot in flying his aircraft.

Answers to Frame 7: __✓__a. _____b. __✓__c.

1398

Frame 9

The VGH recorder and servo accelerometer are checked on the flight line using the TTU-226/E test set. The test set hook-up is shown in figure 4.

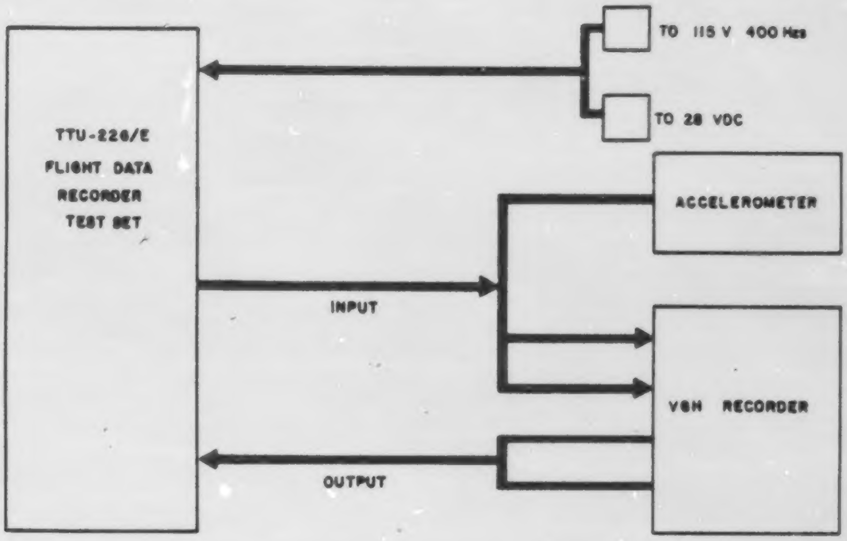

TO 115 V 400 Hz
TO 28 VDC
TTU-226/E
FLIGHT DATA
RECORDER
TEST SET
ACCELEROMETER
INPUT
VGH RECORDER
OUTPUT

Figure 4.

Note: Always use a technical order when performing checks on the system. Be sure to perform the steps in sequence. Do not skip any steps because the test equipment may easily be damaged along with the flight data recorder system.

Check (✓) statements which best describe the purpose of the TTU-226/E tester.

_____a. To supply inputs and monitor outputs.

_____b. To supply inputs.

_____c. To supply outputs.

_____d. To monitor inputs and supply outputs.

Answers to Frame 8: 1. _____a. __✓__b. _____c. _____d.

2. __✓__a. _____b. _____c. _____d.

Frame 10

The tape magazine cannot be checked on the aircraft, it must be removed and taken to the shop. It is checked in the shop with same type of tester, the TTU-226/E and a dual trace oscilloscope. The hook-up for bench checking of the tape magazine is shown in figure 5. If the tape magazine is bad, it must be replaced with a fresh magazine, while the bad one is sent to the depot for repair.

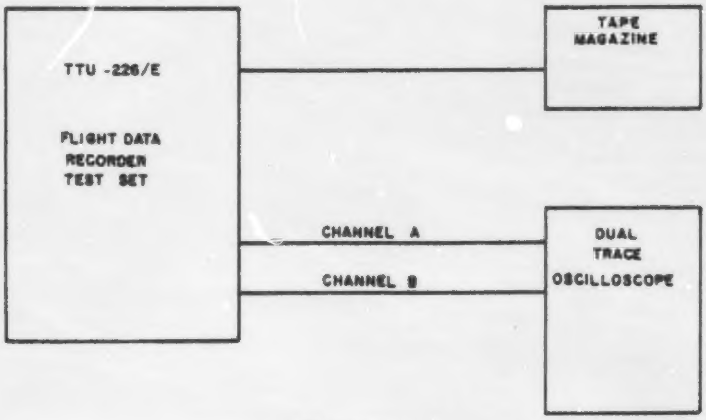

TTU -226/E
FLIGHT DATA RECORDER TEST SET
TAPE MAGAZINE
CHANNEL A
CHANNEL B
DUAL TRACE OSCILLOSCOPE

Figure 5.

Check (✓) the correct statement.

Which of these testers are used to check the tape magazine?

_____a. The TTU-229/E.

_____b. The TTU-226/D.

_____c. The TTU-226/E.

_____d. The TTU-229/D.

Answer to Frame 9: __✓__a. _____b. _____c. _____d.

Frame 11

To properly understand the flight data recorder, you must be able to read binary numbers. When reading binary numbers you will see only a 0 (zero) or a 1 (one) in each column. A sample binary number is shown in figure 6. These columns are read from right to left. The first column is the decimal 1, the next is the decimal 2. This can be continued by doubling the decimal number as you go on. Look at figure 7. To read this number, all you would have to do is place decimal numbers above each column, from right to left, doubling the decimal numbers as you go to the next column. Add the decimal numbers that have a 1 (one) in their column. This gives you the total decimal number. In other words, there is one 1, no 2, no 4, one 8, and no 16. This makes a total of 9. Look at figure 8 and find the decimal of the binary 00011. You can see that one 1 and one 2 makes a total of 3.

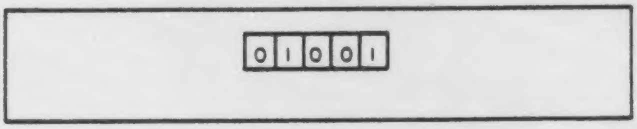


Figure 6.

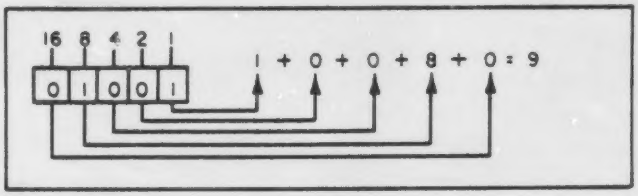


Figure 7.

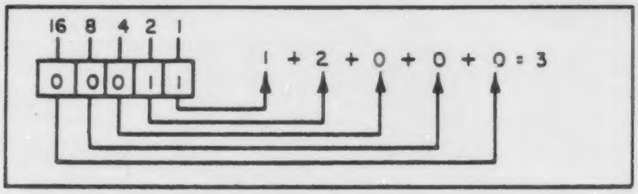


Figure 8.

Check (✓) the true statement(s) below.

_____a. The binary for 3 is 00001.

_____b. The binary for 7 is 00111.

_____c. The binary for 8 is 01001.

Answers to Frame 10: 1. _____a. _____b. __✓__c. _____d.

Frame 12

The multichannel recorder system, Airborne Signal Data Recorder, of ASIP is somewhat more complex than the Flight Data Recorder discussed earlier in the programmed text. As an example of a multichannel recorder system, this section of the text will cover the F-111 Airborne Signal Data Recorder system.

This airborne signal data recording system consists of electrical system sensors that provide input information from selected points throughout the aircraft. The recorder set will process the aircraft data as supplied by the sensors. A tape magazine will record the data on a thirty (30) track magnetic tape. The magazine is equipped with a tape remaining indicator that shows the hours of tape available for use through a window display.

In the airborne signal data system all inputs to the recorder are electrical inputs as provided by the aircraft sensors. These inputs are processed and converted to binary number outputs to the tape magazine for recording purposes.

Check (✓) the most correct answer.

1. How many recording channels does the airborne signal data recorder have?

_____a. Five channels.

_____b. Thirteen channels.

_____c. Thirty channels.

_____d. Forty channels.

2. What are the electrical signals from the sensors converted to?

_____a. Trinomial numbers.

_____b. Decimal numbers.

_____c. Binomial numbers.

_____d. Binary numbers.

3. What type sensors are used by the Airborne Signal Data Recorder?

_____a. Pneumatic sensors.

_____b. Pneumatic and electrical sensors.

_____c. All electrical sensors.

_____d. Binary sensors.

Check (✓) the most correct answer.

4. What does the window display on the multichannel recorder set indicate?

_____a. The number of feet of tape available for use.

_____b. The number of hours of tape used.

_____c. The number of hours of tape available for use.

_____d. The number of feet of tape used.

Answers to Frame 11: _____a. __✓__b. _____c. _____d.

Frame 13

There are thirteen sensor units involved in the F-111 airborne signal data recording system. Some of these sensor units have multiple outputs, for example, the central air data computer provides three outputs which are used by the recorder. Even though the central air data computer provides three outputs, it is considered one single sensor unit.

Following are the thirteen sensor units.

1. WINGSWEEP TRANSMITTER - Converts mechanical position of the wings to an electrical signal of degrees that is sent to the recorder.

2. FLAP POSITION TRANSMITTER - Converts mechanical position of the flaps to an electrical signal of degrees that is sent to the recorder.

3. HORIZONTAL TAIL TRANSMITTERS - Converts mechanical position of left and right horizontal tail surfaces into electrical signals of degrees and sends them to the recorder.

4. RUDDER POSITION TRANSMITTER - Converts mechanical position of rudder in degrees left and degrees right which is sent to the recorder.

5. SPOILER POSITION TRANSMITTER - Converts mechanical position of each spoiler to an electrical up or down signal which is then sent to the recorder.

6. LANDING GEAR SWITCH - A switch located on the main strut will send an electrical signal to the recorder indicating landing gear up or landing gear down.

7. LANDING GEAR PRESSURE TRANSDUCERS - Converts pneumatic pressure in the landing gear struts to an electrical signal for use by the recorder.

8. TRIAXIAL LINEAR ACCELEROMETER - Sends signal proportional to the aircraft acceleration along longitudinal, lateral, and vertical axes.

9. FLIGHT CONTROL SENSOR SET - Relays roll, yaw, pitch rates to the recorder in the form of electrical signals.

10. CENTRAL AIR DATA COMPUTER - Supplies electrical signals of mach number, AOA (angle of attack), and altitude to the recorder.

11. SINK RATE RADAR SET - Used when the landing gear is down during landings for an accurate reading of altitude of thirty feet or less. The set will generate, transmit, and receive a microwave signal using an antenna which is an integral part of the receiver-transmitter unit. The electrical sink rate signal is then sent to the recorder.

12. TOTAL TEMPERATURE INDICATOR - Will relay an electrical signal of outside air temperature to the recorder.

13. FUEL FLOW INDICATORS - Sends an electrical signal relating to the fuel consumption of each individual engine during the flight.

Frame 13 Continued

Match the sensor unit with their respective electrical output signal.

SENSOR UNIT

_____1. Flap position transmitter

_____2. Triaxial linear accelerometer.

_____3. Fuel flow indicators

_____4. Central air data computer

_____5. Horizontal tail transmitters

_____6. Landing gear pressure transducers

_____7. Total temperature indicators

_____8. Spoiler position transmitter

_____9. Landing gear switch

____10. Sink rate radar set

____11. Wingsweep transmitter

____12. Flight control set

____13. Rudder position transmitter

SIGNAL

a. Sends signal pertaining to fuel consumption.

b. Degrees left and right of center of the rudder.

c. Position of wings in degrees.

d. Yaw, roll and pitch rates.

e. Altitude readings of 30 feet or less.

f. Landing gear up or down.

g. Outside air temperature.

h. Pressure in the landing gear struts.

i. Altitude, mach number, AOA.

j. Position of each spoiler.

k. Position of the flaps in degrees.

l. Acceleration along longitudinal, lateral, and vertical axes.

m. Position of tail surfaces.

Answers to Frame 12:
1. _____a. _____b. __✓__c. _____d.
2. _____a. _____b. _____c. __✓__d.
3. _____a. _____b. __✓__c. _____d.
4. _____a. _____b. __✓__c. _____d.

1365

Frame 14

When the tape magazine leaves the aircraft, it is inserted into a tape to tape copier. The data on the tape of the tape magazine is transferred to a standard reel. After this is accomplished, the used magnetic tape is erased and replaced in the aircraft. The taped standard reel is sent to base supply where it is air mailed to a central facility for processing. The processed data is then used, along with the aircraft forms, by the aircraft builder to update fatigue analysis.

The updated fatigue analysis affects:

1. Predictions of fleet service life.

2. Scheduling of structural modification.

3. Determination of maintenance inspection requirements for aircraft structure.

4. Headquarters USAF structural planning.

In effect, the information is used to determine and correct troubles before they occur, the old concept of preventative maintenance still applies.

NO RESPONSE REQUIRED

Answers to Frame 13: k 1. l 2. a 3. i 4. m 5. h 6.

g 7. j 8. f 9. e 10. c 11.

d 12. b 13.

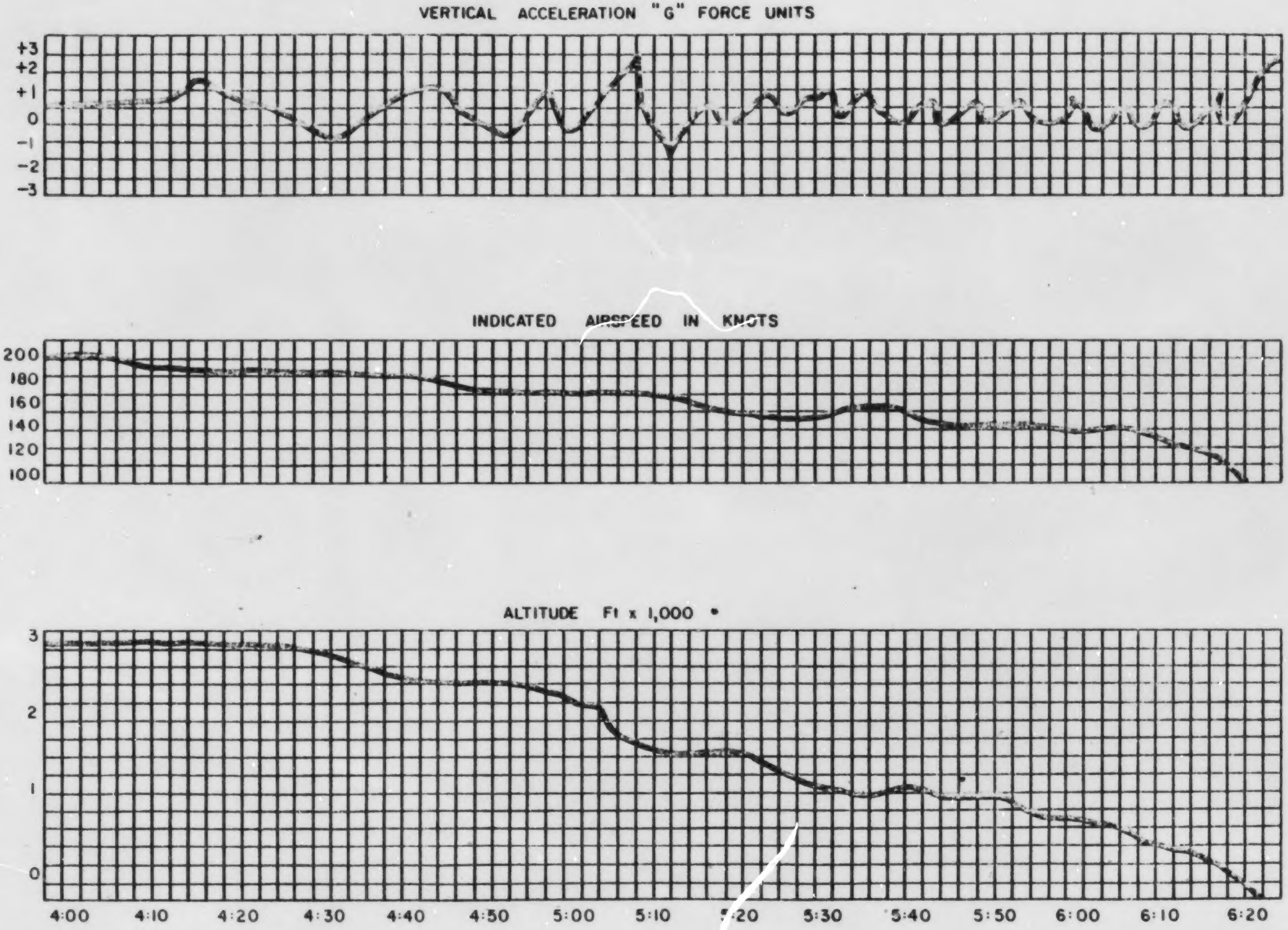
1406

Frame 15

In case of an accident, these magnetic tapes are used to monitor the flight and, in a sense, act as a witness to the crash. In the example shown in figure 9, a C-141 was four minutes and eleven seconds into its flight when it began to descend rapidly. Note the aircraft's rate of descent beginning at seven seconds prior to impact. Also note the extreme G forces sensed upon impact.

NO RESPONSE REQUIRED

Answer to Frame 10: _____a. _____b. _✓_c. _____d.


VERTICAL ACCELERATION "G" FORCE UNITS

INDICATED AIRSPEED IN KNOTS

ALTITUDE Ft x 1,000

Figur 9.

PROGRAMMED TEXT
3ABR32531-PT-304
3ABR32632B-PT-404

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

CENTRAL AIR DATA COMPUTER SYSTEM OPERATION

7 September 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR32531 course. This text was validated using 31 students from the subject course. At least 90 percent of the students achieved the approved objectives as stated. The average time to complete the text was 6 hours and 47 minutes.

OBJECTIVES

1. Without references, identify facts pertaining to the operation and/or characteristics of air data computer systems with an accuracy of at least 80%.

INSTRUCTIONS

This programmed text consists of three sections. Section A covers the operation of the Central Air Data Computer. Section B covers the operation of the amplifiers and indicators used in the system. Section C is designed to provide you with practice circuit tracing and circuit analysis. Each section presents information in small steps called "frames". After reading the information in each frame, you are to answer the questions by following the instructions in each frame. Check the accuracy of your responses by looking at the correct answers given after the following frame. If you choose the wrong response, go back and read the frame again. Read the material carefully and DO NOT HURRY.

Supersedes 3ABR32531-PT-304, 3ABR32632B-PT-404, 11 August 1976.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360TCHTG/TTGU-F - 200; TTVSA - 1

SECTION A

This part of the text will be dealing with the Central Air Data Computer of the FB-111A aircraft. This computer is similar to the AIMS computers, CPU-46/A and CPU-66/A.

The computer receives pneumatic inputs from the pitot-static system, a temperature input from a temperature probe mounted outside the aircraft and a signal of angle-of-attack from the angle-of-attack transmitter. A wing sweep sensor sends a signal to the computer for wing sweep.

These inputs are computed and various output functions are transmitted electrically to the using systems or subsystems on the aircraft. Outputs of the computer are used by the following systems or subsystems: marker beacon, terrain following radar, flight director, landing gear warning, flight controls, altitude vertical velocity indicator and airspeed-mach indicator. The true airspeed indicator, engine bleed air ejector, engine spike, caution lamps, environmental controls, converter set, inertial navigation and visual attack set also use signals from this computer.

So as you can see, the Central Air Data Computer is a very important piece of equipment on the aircraft. Your responsibility of maintaining this equipment is critical to aircraft operations. Therefore, you must understand the purpose, operation and functions of the Central Air Data Computer (CADC).

No Response Required

Frame 1

When studying any equipment, the first step is to learn the purpose and get this firmly in your mind. After that, the operation will just supplement the purpose.

The purpose of the Central Air Data Computer is to compute and transmit surrounding air data to various aircraft systems and subsystems.

Circle the number that identifies the correct answer.

The purpose of the Central Air Data Computer is to:

1. Measure the characteristics of the air surrounding the aircraft.

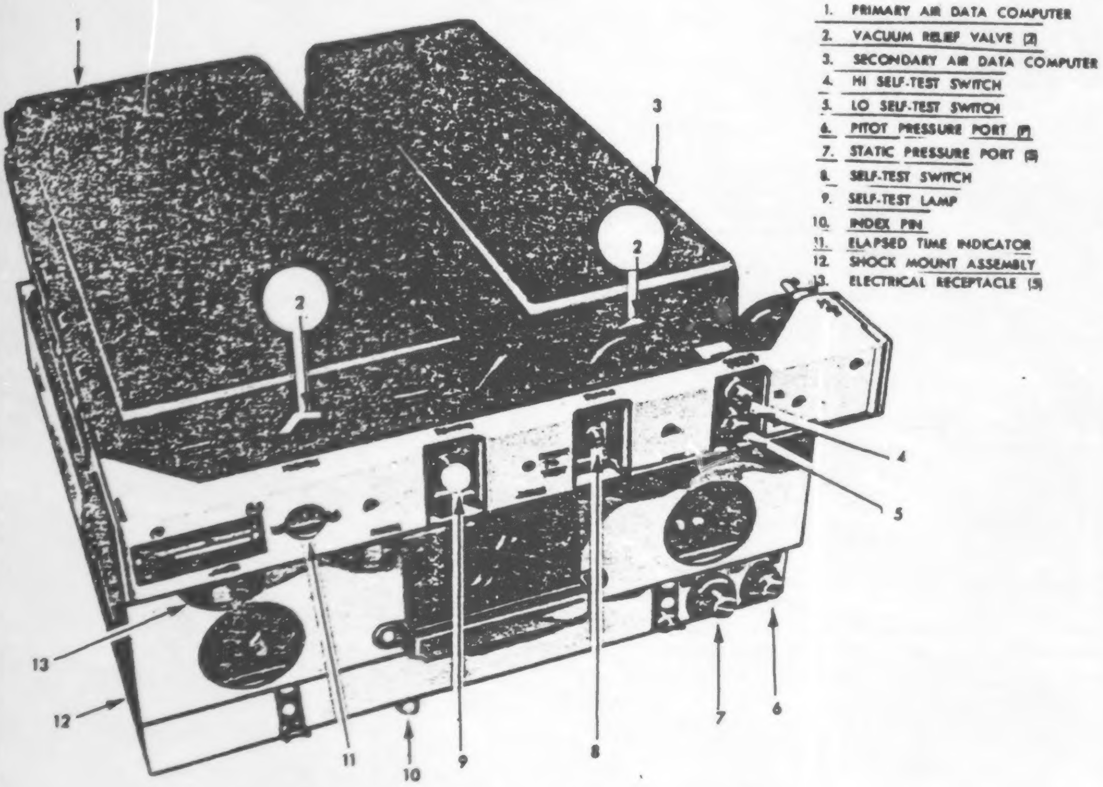
2. Measure the immediate atmosphere through which the aircraft is flying.

3. Compute and indicate the speed and altitude at which the aircraft is flying.

4. Compute and transmit surrounding air data to various aircraft systems and subsystems.

Frame 2

The CADC consists of a primary ADC and a secondary ADC. They are individually mounted on a common shock mount assembly (see figure 1). The primary and secondary computers are electrically interconnected and electrically and pneumatically connected to the aircraft. The CADC system is connected to the aircraft by five receptacles and two pressure ports located on the front panel of the shock mount assembly. The pressure ports are different in diameter. This prevents crossing the static and total pressure lines. The CADC is an analog-type computer. It solves most of its computations with differentials and cams.



1. PRIMARY AIR DATA COMPUTER
2. VACUUM RELIEF VALVE (2)
3. SECONDARY AIR DATA COMPUTER
4. HI SELF-TEST SWITCH
5. LO SELF-TEST SWITCH
6. PITOT PRESSURE PORT (P)
7. STATIC PRESSURE PORT (S)
8. SELF-TEST SWITCH
9. SELF-TEST LAMP
10. INDEX PIN
11. ELAPSED TIME INDICATOR
12. SHOCK MOUNT ASSEMBLY
13. ELECTRICAL RECEPTACLE (5)

Figure 1. Central Air Data Computer.

Circle the number(s) that identify the correct answer(s).

What type computer is used in the FB-111 aircraft?

1. Digital.
2. Analog.
3. Digital to analog.
4. Analog to digital.

Answer to frame 1: 4

1373

Frame 3

In your study of the Central Air Data Computer System, it is of utmost importance that you learn certain terms and symbols. All inputs and outputs of the computer system are identified by these symbols. In order to understand this system, you must become familiar with them. Throughout this programmed text, you will find that as each major component is discussed, the terms and symbols that are pertinent to that component will be used and discussed.

Below is a list of abbreviations and symbols for the major components of the Central Air Data Computer System.

CADC	Central Air Data Computer
ADC	Air Data Computer
Ti	Total Temperature
G	Unit of Measurement of Gravity
CADCS	Central Air Data Computer System
AMI	Airspeed Mach Indicator
$\propto$ i	Indicated Angle-of-Attack
Psi	Indicated Static Pressure (Uncorrected)
AVVI	Altitude Vertical Velocity Indicator

Fill in the blanks in the following statements with the correct terms and/or symbols.

1._____ Central Air Data Computer

2._____ Air Data Computer

3._____ Total Temperature

4._____ Indicated Angle-of-Attack

5._____ Altitude Vertical Velocity Indicator

6._____ Airspeed Mach Indicator

7._____ Central Air Data Computer System

Answers to frame 2: 2

1415

Frame 4

The following is a list of primary inputs and outputs of the CADC.

CADC OUTPUTS

1. M - Mach
2. Hp + Λ - Wing Sweep Angle.
3. Hp - Pressure Altitude.
4. $H\dot{p}$; Hp^1; Hpr - Pressure Altitude Rate. (Rate of Climb)
5. Tfat - True Free Air Temperature.
6. Vc - Calibrated Airspeed.
7. α T - True Angle-of-Attack.
8. Vt - True Airspeed.

CADC INPUTS

1. Psi - indicated static pressure.
2. Pt (Qc+Ps) - total pressure.
3. Ti - total temperature.
4. α i - indicated angle of attack.
5. Λ - wing sweep angle.

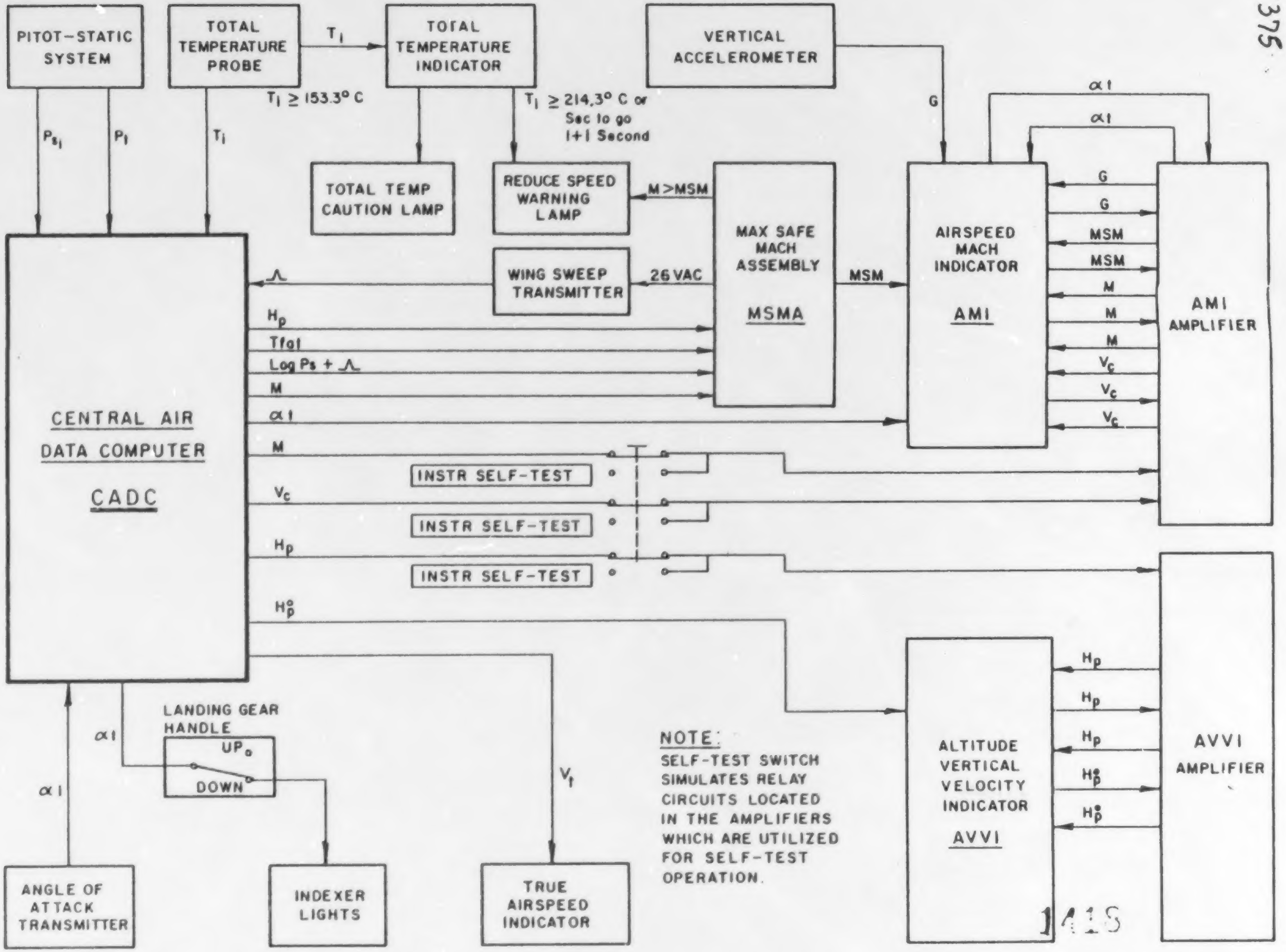
(Ref: Figure 2, CADC Data Flow Block Diagram)

Match the numbered items on the left to the lettered items on the right by writing the letter of the definition beside its correct symbol:

1._____	Pt (Qc+Ps)	a.	Mach
2._____	α i	b.	Calibrated Airspeed
3._____	Vt	c.	True Free Air Temperature
4._____	$H\dot{p}$	d.	Wing Sweep Angle (16° to 72°)
5._____	M	e.	Pressure Altitude
6._____	Λ	f.	Indicated Angle-of-Attack
7._____	psi	g.	Indicated static pressure
8._____	Hp	h.	Total Pressure
9._____	Tfat	i.	True Angle-of-Attack
10._____	Vc	j.	True Airspeed
11._____	α T	k.	Pressure Altitude Rate

Answers to frame 3: 1. CADC 2. ADC 3. Ti 4. αi 5. AVVI 6. AMI 7. CADCS

1375


PITOT-STATIC SYSTEM
TOTAL TEMPERATURE PROBE
T_i
TOTAL TEMPERATURE INDICATOR
VERTICAL ACCELEROMETER
$T_i \geq 153.3°$ C
$T_i \geq 214.3°$ C or Sec to go 1+1 Second
P_{s_i}
P_i
T_i
G
αi
αi
TOTAL TEMP CAUTION LAMP
REDUCE SPEED WARNING LAMP
M > MSM
MAX SAFE MACH ASSEMBLY
MSMA
AIRSPEED MACH INDICATOR
AMI
G
G
MSM
MSM
M
M
M
V_c
V_c
V_c
AMI AMPLIFIER
WING SWEEP TRANSMITTER
26 VAC
MSM
H_p
Ttot
Log Ps + ⩘
M
αi
M
V_c
H_p
$\dot{H}_p$
INSTR SELF-TEST
INSTR SELF-TEST
INSTR SELF-TEST
CENTRAL AIR DATA COMPUTER
CADC
LANDING GEAR HANDLE
UP
DOWN
αi
αi
V_t
NOTE: SELF-TEST SWITCH SIMULATES RELAY CIRCUITS LOCATED IN THE AMPLIFIERS WHICH ARE UTILIZED FOR SELF-TEST OPERATION.
ALTITUDE VERTICAL VELOCITY INDICATOR
AVVI
H_p
H_p
H_p
$\dot{H}_p$
$\dot{H}_p$
AVVI AMPLIFIER
ANGLE OF ATTACK TRANSMITTER
INDEXER LIGHTS
TRUE AIRSPEED INDICATOR

1418

Figure 2. CADC System Data Flow Block Diagram.

1417

Frame 5

You now know the inputs and some of the outputs of the CADC. Use figure 2 CADC Data Flow Block Diagram and trace the inputs to the CADC. Also use figure 2 and trace all the CADC outputs to their destinations.

1. Circle the following symbols that are inputs to the CADC.

   a. Psi

   b. α t

   c. Ti

   d. —^—

   e. Pt

   f. Tfat

2. Circle the following units that send signals directly to the AMI.

   a. CADC.

   b. Vertical accelerometer.

   c. α i XMTR

   d. Ti XMTR.

   e. AVVI Amplifier.

   f. Hp Self-Test.

   g. MSMA.

3. The total temperature probe supplies Ti signal to _____ units.

   a. 2.

   b. 3.

   c. 4.

   d. 5.

1377.

Mark the following statements true or false.

_____4. True Airspeed indicator receives Vt from the AMI amplifier.

_____5. The AMI receives Vt from the CADC.

_____6. The wing sweep transmitter receives _/_ from the CADC.

_____7. Hpr is a symbol for rate-of-climb.

_____8. Vc is a symbol for calibrated airspeed.

_____9. MSM is max-safe-Mach.

Answers to frame 4: 1. h 2. f 3. j 4. k 5. a
6. d 7. g 8. e 9. c 10. b 11. i

1420

Frame 6

Now that you are familiar with the data flow of the CADC, let's discuss the purpose and operation of the units and components that make up the system. The first is the angle-of-attack system. The purpose of the angle-of-attack system is to measure the angle of air flow relative to an arbitrary reference line on the aircraft fuselage, and provides a visual indication of aircraft angle-of-attack. The angle-of-attack transmitter (XMTR) is located on the left rear electronics bay door. This sensing element (see figure 3) protrudes into the free airstream around the fuselage. Movement of the sensor operates a mechanism (Pots) within the transmitter. The AOA XMTR transmits α i signals electrically to the CADC. The CADC computes and transmits α T signals to the AMI and the AOA indexer lights.

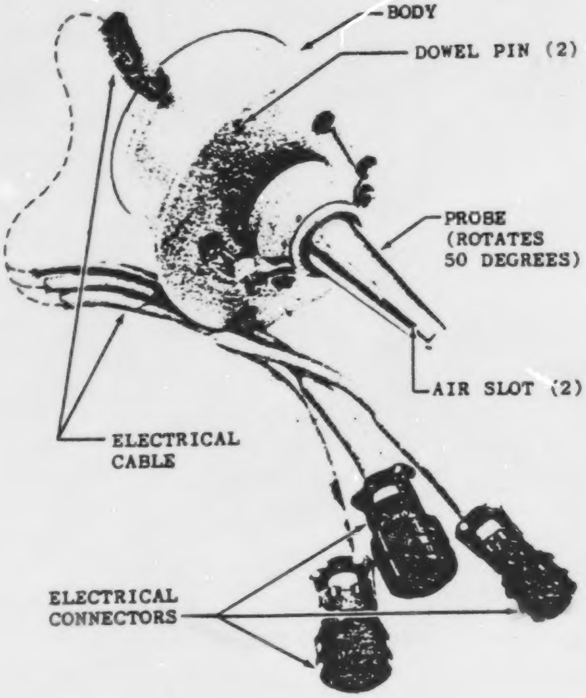


Figure 3. Angle-of-Attack Transmitter (ALPHA PROBE).

Circle the number(s) that identify the correct answer(s).

The purpose of the AOA system is to:

1. Indicate the altitude of the aircraft.

2. Measure the angle of air flow relative to an arbitrary reference line on the aircraft fuselage, and provide a visual indication of aircraft angle-of-attack.

3. Detect relative wind by means of differential air pressure through a series of ports or slots located in the front of the probe.

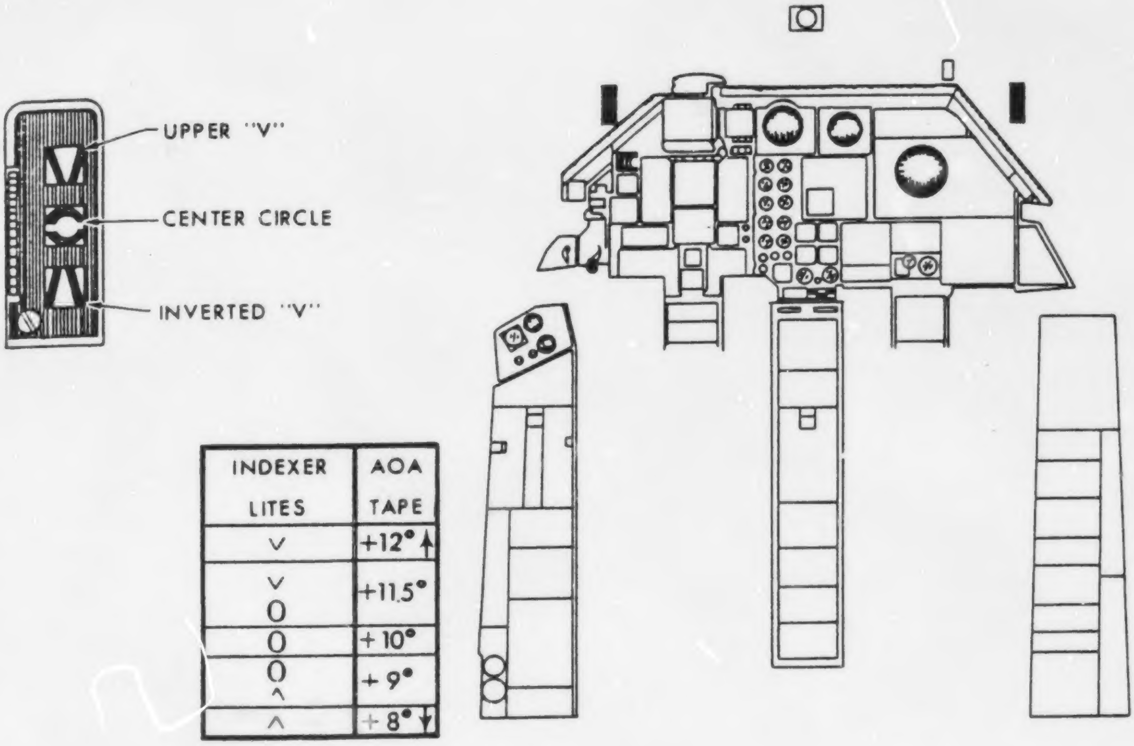
4. Measure the angle between the aircraft water line and the direction of air flow around the AOA transmitter and provides a visual indication of aircraft angle-of-attack.

Answers to frame 5: 1. a, c, d, e 2. a, b, g 3. a 4. F

5. F 6. F 7. T 8. T 9. T

Frame 7

The angle-of-attack indexers (see figure 4) provide a visual indication of the corrected AOA during the landing approach. The cockpit contains two angle-of-attack indexers. The indexers are mounted on each side of the glareshield. Each indexer contains three angle-of-attack lamps vertically arranged in a V, a center circle and an inverted V. The indexers' lights operate only when the landing gear handle is down. They receive α T signals from the CADC. During landing approach, the upper V will light if the angle-of-attack is high. The center circle will light when the correct angle-of-attack is obtained. The lower inverted V will light if the AOA is low. Marginal overlap of signals may cause the center circle and upper or lower V to be lighted at the same time.



INDEXER LITES	AOA TAPE
V	+12° ↑
V O	+11.5°
O	+10°
O ^	+9°
^	+8° ↓

Figure 4. Angle-of-Attack Indexer.

Circle the number(s) that identify the correct answer(s).

During approach to landing, with the landing gear in the up position, the pilot observes a +10° reading on the AOA tape. Which of the following indexer lights will be illuminated?

1. The upper V will be illuminated.

2. The center circle will be illuminated.

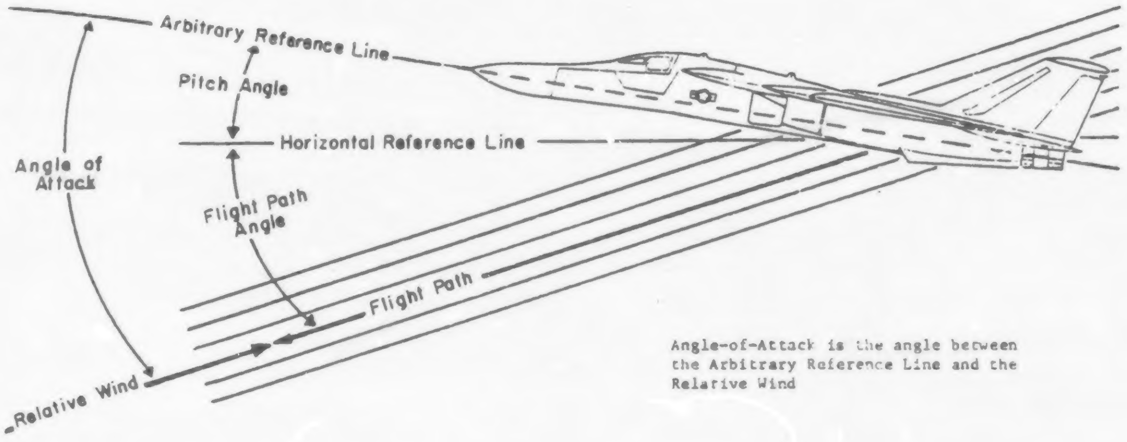
1381

3. The inverted V will be illuminated.

4. No indexer lights will be on.

Answer to frame 6: 2

1924


Arbitrary Reference Line
Pitch Angle
Horizontal Reference Line
Angle of Attack
Flight Path Angle
Flight Path
Relative Wind

Angle-of-Attack is the angle between the Arbitrary Reference Line and the Relative Wind

Figure 4A. Angle-of-Attack.

Angle-of-attack systems are installed in Air Force aircraft to present visual indications of the best aircraft performance and for stall warning. They are primarily used during the approach and landing phases to verify airspeed calculations or indications, and to avoid exceeding high or excessive angles-of-attack. Stalls (loss of lift due to the separation of air from the wing aerodynamic surface), spins, high sink rates, and/or pitch up which are normally associated with low airspeeds, are the results of excessive angles-of-attack.

Stall warning systems may consist of rudder pedal vibrators, control column or control stick vibrators, warning light, and aural warning tones in the headsets or any combination of these. These systems coupled with the indexer lights and angle-of-attack indicators warn the pilot to take corrective measures to avoid entering a stall, spin, high sink rate, and/or pitch up conditions.

No Response Required

1383

Frame 9

The total temperature probe senses the temperature of the air through which the aircraft is moving. It electrically transmits this signal to the total temperature indicator and the CADC. In flight, the forward motion of the aircraft forces air into the total temperature probe opening (see figure 5). Inside the probe, the air passes over two sensing elements. It then forces its way through smaller outlet ports at the back of the probe. Flow of the air over the sensing elements produces a temperature change. This causes a resistance change of the sensing elements. This change in resistance is electrically transmitted to the total temperature indicator and the CADC. The probe is electrically heated for anti-icing purposes and is controlled by the pitot heat switch located on the anti-ice panel.

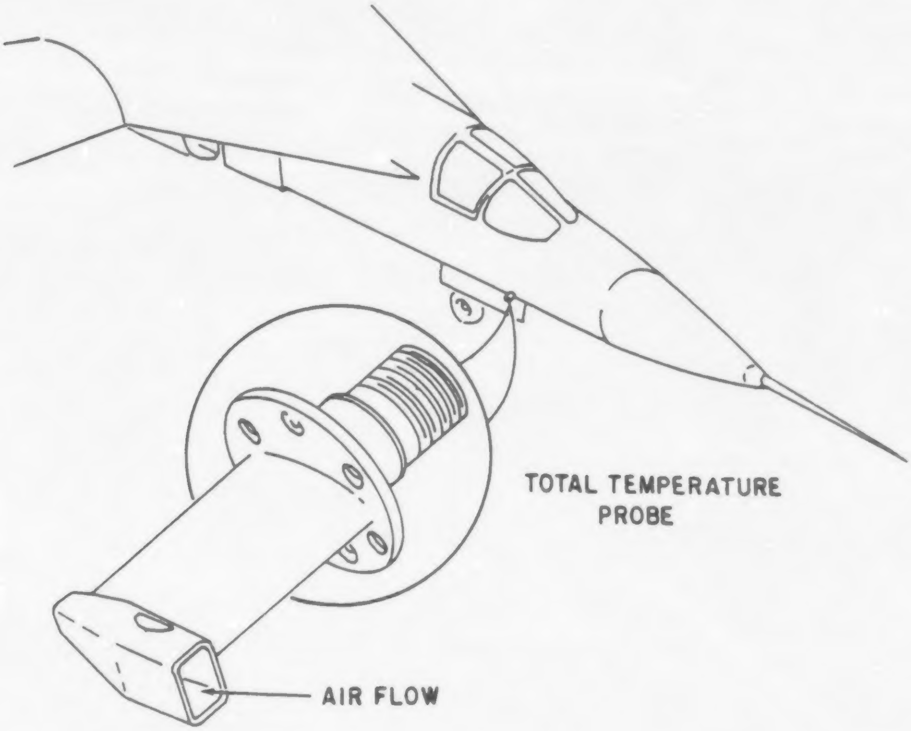


Figure 5. Total Temperature Probe.

Circle the number(s) that identify the correct answer(s).

The total temperature probe

1. has two sensing elements.
2. senses total pressure (ram air).

3. mechanically transmits temperature signals.

4. has an anti-icing system.

Answer to frame 7: 4

1385

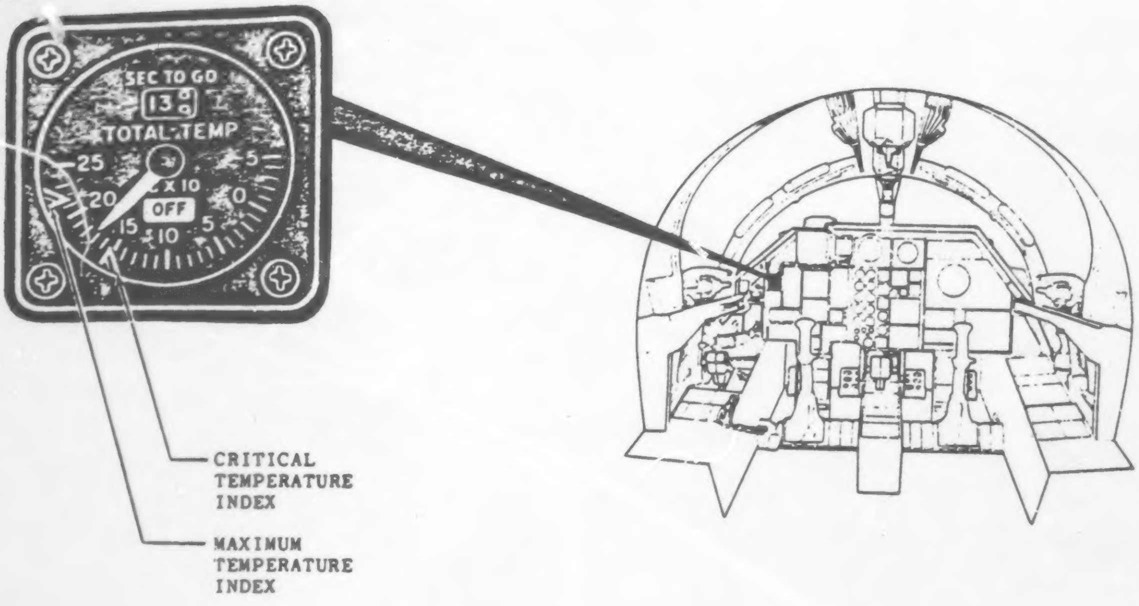

SEC TO GO
13
TOTAL TEMP
25
20
15
10
5
0
5
°C x 10
OFF
CRITICAL TEMPERATURE INDEX
MAXIMUM TEMPERATURE INDEX

Figure 6. Total Temperature Indicator.

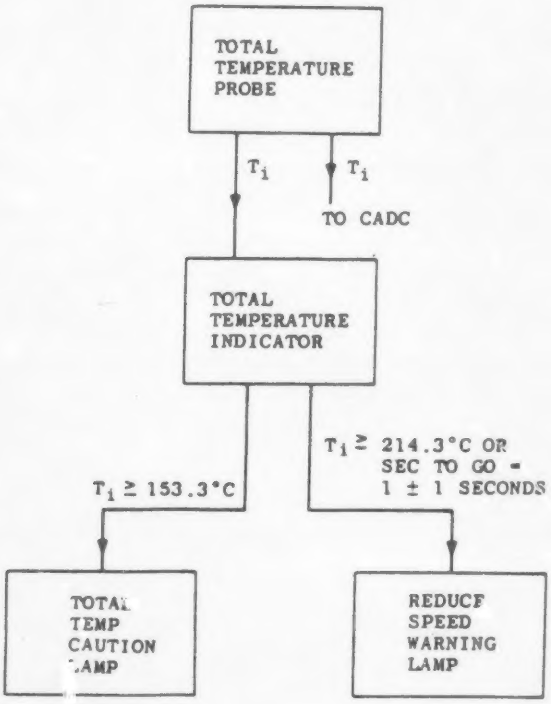

TOTAL TEMPERATURE PROBE
T_i
T_i
TO CADC
TOTAL TEMPERATURE INDICATOR
$T_i \geq 153.3$°C
$T_i \geq 214.3$°C OR SEC TO GO = 1 ± 1 SECONDS
TOTAL TEMP CAUTION LAMP
REDUCE SPEED WARNING LAMP

Figure 7. Total Temperature Data Flow Diagram.

1928

Frame 10

The total temperature indicator displays the temperature of the air sensed by the total temperature probe. The indicator, shown in figure 6, provides total temperature readings from -50°C to +250°C. The indicator has index marks at 153.3°C critical temperature and 214.3°C maximum temperature. The total temperature circuit consists of a remote temperature probe, a bridge circuit, signal amplifier and a motor that drives the indicator pointer. The total temperature data flow is shown in figure 7.

No Response Required

Answers to frame 9: 1, 4

Frame 11

The critical temperature range is from 153.3°C to 214.3°C. The aircraft should not fly in this temperature range for more than 300 seconds because to do so might be harmful to the aircraft. Whenever the aircraft flies in the critical temperature range for 300 seconds, a timer causes a reduce speed warning lamp to light and the total temp light to go out. The pilot then must reduce airspeed to allow the temperature to decrease to a safe level. The reduce speed warning lamp will also light anytime the maximum temperature of 214.3°C is reached. The time totalizing counter starts timing whenever the critical temperature, 153.3°C is reached. The counter counts down from 300 seconds to zero seconds. It causes a total temperature caution lamp to light at 298 ± 2 seconds. If the temperature remains above 153.3°C for 300 ± 1 second, the reduce speed lamp lights, and the total temp light goes out.

Mark the following statements T for true or F for false.

_____1. When the total temperature is 173.3°C and the timer has been counting for 198 seconds, the reduce speed lamp will be lit.

_____2. The total temperature is above 215°C. The reduce speed lamp will be lit.

_____3. After the total temperature has been at 143.3°C for 20 seconds, the total temperature lamp will be lit.

Frame 12

The maximum safe mach assembly (MSMA) computes the maximum safe mach number at which the aircraft can fly without exceeding temperature or structural limitations. The MSMA receives input signals from the central air data computer. It then transmits a computed signal to the airspeed-mach indicator and the reduce speed lamp. The MSMA performs the same function as the maximum allowable section of the maximum allowable airspeed indicator covered earlier. The MSMA receives M, Hp, Tfat and Log Ps + ⌃ from the CADC (receiver figure 2). Using the above inputs, the MSMA computes the max speed the aircraft may fly at any altitude. The outputs of the MSMA are applied to the maximum safe mach bar in the AMI and to the reduce speed lamp. If the actual flight mach is greater than the MSM, the following will occur:

1. MSM bar will move above the lubber line on the AMI.

2. 28V DC will be applied to the reduce speed lamp and the lamp will glow.

Circle the number(s) that identify the correct answer(s).

The purpose of the MSMA is to

1. indicate the maximum safe mach the aircraft can fly.

2. compute the maximum safe mach the aircraft can fly.

3. measure the maximum safe mach the aircraft can fly.

4. position the MSM bar above the lubber line on the AMI.

Answers to frame 11: 1. F 2. T 3. F

Frame 13

The self-test circuit that is built into the CADC is designed for preflight testing and troubleshooting the CADC system in the aircraft on the ground. The circuit provides a means of checking the computation and servo accuracy of the CADC. Self-test can be done from either the cockpit or the front panel of the CADC. The CADC HIGH-OFF-LOW switch, when placed in either the HIGH or LOW position, energizes self-test relays. These relays, when energized, bypass the Psi and Pt transducers, the total temperature probe and the angle-of-attack transmitter. The self-test relays allow preselected values of Psi, Pt, Ti and α i to be fed to the computing section of the CADC. The CADC, if operating properly, computes known values for mach, altitude indicated airspeed, etc. These values are displayed on the AMI, AVVI and the true airspeed indicator. The values that are displayed for both HIGH and LOW self-test are listed in figure 8. To perform self-test from the front panel of the CADC, hold the PRESS TO TEST switch and the HI-OFF-LOW SELF-TEST switch in either the Hi or Lo position. Actuation of the two switches causes the CADC to compute and transmit signals to the indicators. The AMI, AVVI and TAS will position to the known values listed in figure 8 for either HIGH or LOW self-test.

SELF-TEST VALUES CADC SYSTEM

	Tapes or Indicator	CADC SELF-TEST				INSTRUMENT SELF-TEST	
		High	Tol. +or-	Low	Tol. +or-	Instruments	Tol. +or-
AMI	AOA	10°	.75	7°	.75	—	—
	G	—	—	—	—	—	—
	M	2.3 M	.05	.4 M	—	2.44 M	.01
	Vc	493 Kts	12	153 Kts	11	800 Kts	10
AVVI	Vertical Velocity	Climbing or Diving to 40,000 FPM	—	—	—	—	—
	Sensitive Altitude	60,000'	130	2,000'	130	74,000'	150
	Gross Altitude	60,000'	130	2,000'	130	74,000'	150
TAS	True Airspeed Indicator (TAS)	1348.8 Kts	13	157.6 Kts	13	—	—

Figure 8.

1432

Circle the number(s) that identify the correct answer(s).

When the self-test relays are energized, which of the following preselected signal values are being fed to the computing section of the CADC?

1. αt, Ps, Pt and Hp.
2. Psi, M, αi and Pt.
3. Pt, Psi, Ti and αi.
4. Ti, Psi, Pt and Vc.

Answer to frame 12: 2

Frame 14

Now that you have learned about the inputs and outputs of the CADC, and also the CADC self-test, there is only one item left to explain about the CADC. This item is the CADC system monitor circuits. The purpose of these circuits is to show the pilot or technician that a trouble exists in the CADC system. The monitor circuit performs this function by lighting a CADS lamp. This lamp is located on the caution panel in the cockpit. Remember, the monitor circuits do not indicate that a malfunction exists in a certain unit such as the AMI amplifier, AVVI or the CADC. The monitor circuit shows only that there is a trouble somewhere in the CADC system.

No Response Required

Answer to frame 13: 3

Frame 15

This concludes section "A" of this programmed text. Answer the review questions at the end of this frame and then proceed to section "B" of this PT.

Match the numbered items on the left to the lettered items on the right. Write the letters of the proper definition to the left of its term or symbol. You have not been taught all these terms and symbols before this time. After you have answered the ones you know, copy the answers to the remaining ones from the answer key at the bottom of this frame. Once you have all the correct answers, study these terms and symbols.

1._____ Hp
2._____ MSM
3._____ Psi
4._____ Pt (Qc+Ps)
5._____ Qci
6._____ MSMA
7._____ α i
8._____ Ps
9._____ α t
10._____ Δ Hp
11._____ Vt
12._____ α
13._____ AMI
14._____ AVVI
15._____ —∧—
16._____ >
17._____ <
18._____ Vc
19._____ Ti
20._____ Tfat

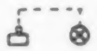
a. Angle-of-attack
b. Maximum safe mach assembly
c. Wing sweep angle
d. Motor-Generator unit
e. Pressure altitude
f. Total pressure
g. Indicated differential static pressure
h. Altitude vertical velocity indicator
i. Value greater than
j. True free air temperature
k. Differential
l. Calibrated airspeed
m. Incremental (Change) pressure altitude
n. True static pressure
o. Indicated static pressure
p. Maximum safe mach
q. Rate of climb
r. Indicated angle-of-attack
s. True airspeed
t. Antilogging differential and cam

1393

21._____ Ⓜ -- Ⓖ u. Total temperature

22._____ ⊗ v. Value less than

23._____ —▷— w. Airspeed mach indicator

24._____  x. True angle-of-attack

25._____ $\dot{H}p$ y. Amplifier

26. Identify the inputs to the CADC by circling the correct letters below:

a.	∝ t	f.	∝ i
b.	Vc	g.	—∧—
c.	Ps + Qc	h.	Vt
d.	Pt	i.	Psi
e.	Ti	j.	Hp

27. Identify outputs from the CADC by circling the correct outputs below:

a.	∝ t	f.	Hp
b.	Vc	g.	M
c.	Pt	h.	∝ i
d.	Ps + Qc	i.	Ti
e.	Vt	j.	Hp
		k.	MSM
		l.	Hp + —∧—

Answers to frame 15: 1. e 2. p 3. 0 4. f 5. g
6. b 7. r 8. n 9. x 10. m 11. s 12. a
13. w 14. h 15. c 16. i 17. v 18. l 19. u
20. j 21. d 22. k 23. y 24. t 25. q

26. c, d, e, f, g, i 27. a, b, e, f, g, j, l

APPRAISAL

1436

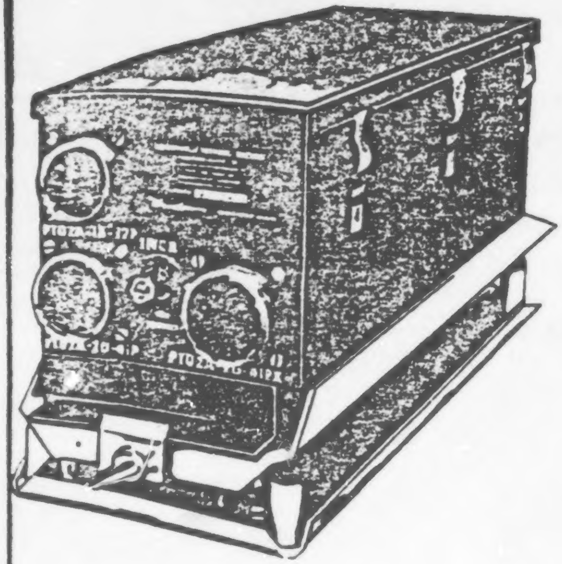


Figure 9. Airspeed-Mach Amplifier.

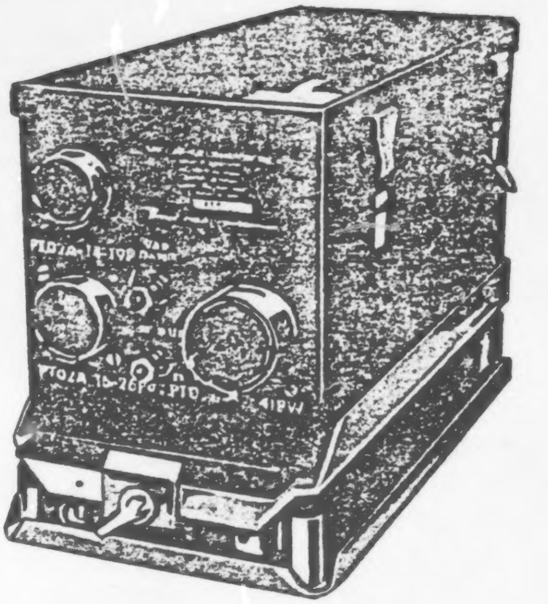


Figure 10. Altitude-Vertical Speed Amplifier.

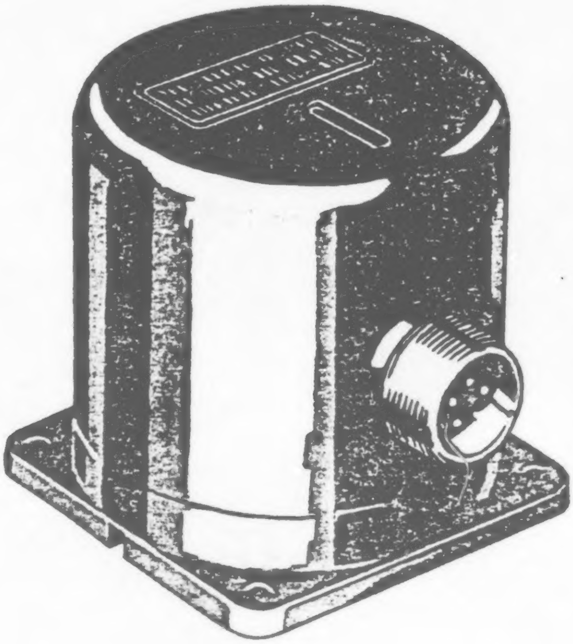


Figure 11. Accelerometer Transmitter.

APPRAISAL

SECTION B

OPERATION OF THE AMI AND AVVI AMPLIFIERS AND INDICATORS

Frame 16

The altitude-vertical speed amplifier is shown in figure 10. It serves as a power supply and amplifier for the AVVI. The amplifier has ZERO SET and VAR DAMP screwdriver adjustments. The ZERO SET adjustment is used to zero the vertical speed tape. The VAR DAMP is used to adjust the damping of the vertical speed tape.

The airspeed-mach amplifier is shown in figure 9. It serves as a power supply for the AMI. It amplifies the mach, calibrated airspeed, maximum safe mach and the true angle-of-attack signals. The amplifier has a VAR DAMP adjustment which is used to adjust the damping of the angle-of-attack tape on the AMI.

The accelerometer transmitter is shown in figure 11. It supplies the "G" force signal to the AMI. This signal is also amplified by the airspeed-mach amplifier.

No Response Required

Frame 17

The Airspeed-Mach indicator is shown in figure 12. It is located on the left main instrument panel. The purpose of the AMI is to present vertical indications of α T, G, Mach, and calibrated airspeed information. Below the moving tapes from left to right are the acceleration counter, a command mach counter, and a command airspeed counter. The electrical signals for operation of the tapes and markers are supplied by the CADC, MSMA and a remote accelerometer. Power for the AMI operation is supplied by the 115V AC system through the AMI amplifier. If loss of AC indicator power occurs, spring-loaded warning flags marked OFF will appear. The OFF flags will appear across the mach indicator scale and airspeed scale.

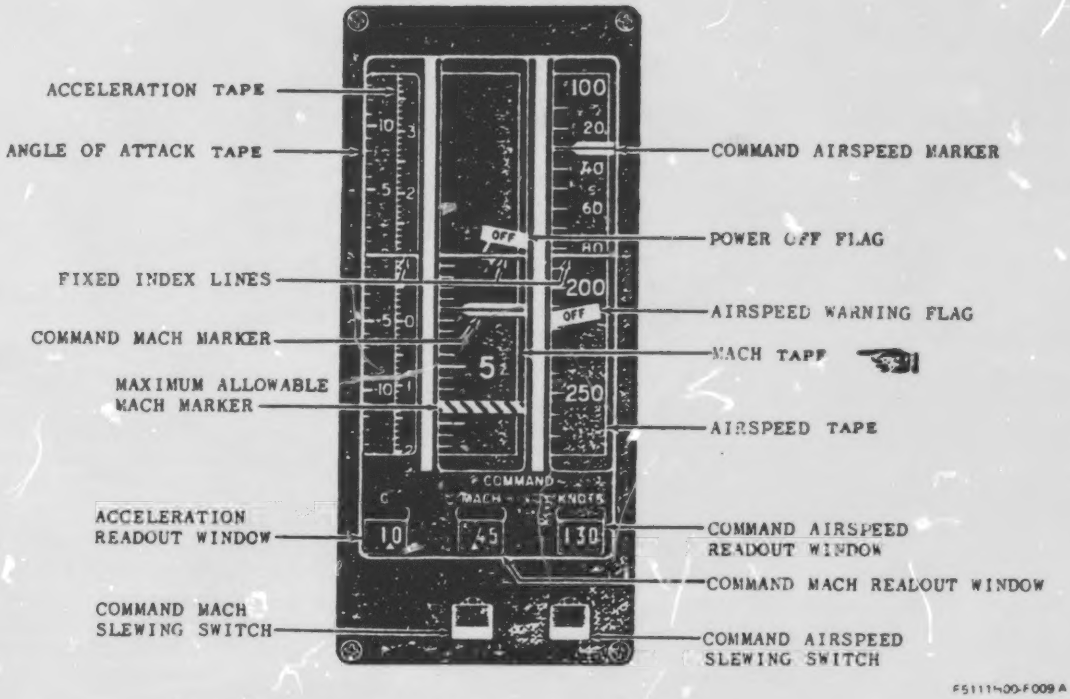

ACCELERATION TAPE
ANGLE OF ATTACK TAPE
FIXED INDEX LINES
COMMAND MACH MARKER
MAXIMUM ALLOWABLE MACH MARKER
ACCELERATION READOUT WINDOW
COMMAND MACH SLEWING SWITCH
COMMAND AIRSPEED MARKER
POWER OFF FLAG
AIRSPEED WARNING FLAG
MACH TAPE
AIRSPEED TAPE
COMMAND AIRSPEED READOUT WINDOW
COMMAND MACH READOUT WINDOW
COMMAND AIRSPEED SLEWING SWITCH
OFF
OFF
COMMAND
MACH
KNOTS
G
10
45
130
100
20
40
60
80
200
250
5
F5111400-F009 A

Figure 12. Airspeed-Mach Indicator.

Circle the letter(s) that identify the correct answer(s).

The purpose of the airspeed indicating section is to indicate:

1. True airspeed.
2. True airspeed and command airspeed.
3. α T, G, Mach, and calibrated airspeed information.
4. Maximum allowable airspeed and calibrated airspeed.

Frame 18

The Mach tape in the center of the AMI indicates true Mach numbers. The Mach number is shown on a moving tape and is read against the fixed index. The tape is calibrated in hundredths and shows numbers in tenths from 0.4 through 3.0. At speeds below Mach 0.4, the tape will continue to read 0.4. A command Mach marker and a command Mach counter indicate the manually selected command Mach. The command Mach marker remains at the top or the bottom of the display column until the selected command Mach comes into view on the Mach tape. At this time, the marker will synchronize and move with the reading on the tape. The selected command Mach is numerically displayed in the command Mach readout window at all times. The command Mach setting is controlled manually by the command Mach slewing switch. When selecting a command Mach number, slewing speed is controlled by the amount you move the slewing switch from its center position.

Circle the number(s) that identify the correct answer.

The command Mach is set into the AMI by:

1. An electrical signal from the CADC.

2. An automatic signal from a ground station.

3. The instrument repairman before takeoff.

4. Manually depressing the slew switch on the bottom center of the AMI.

Answer to frame 17: 3

Frame 19

Maximum safe Mach is shown by a striped maximum allowable Mach marker. The marker normally rests at the bottom of the Mach display column. When the maximum allowable speed is approached, the marker will move up towards the fixed index line. Anytime the striped marker is above the fixed index line, the reduce speed warning light will come on. The pilot should decrease speed because he is exceeding the design limits of the aircraft. The maximum allowable Mach marker is operated by electrical signals from the MSMA.

Circle the number(s) that identify the correct answer.

The AMI receives the MSM signal from:

1. The command Mach slew switch.
2. The Mach section of the CADC.
3. The AVVI amplifier.
4. The max safe Mach assembly.

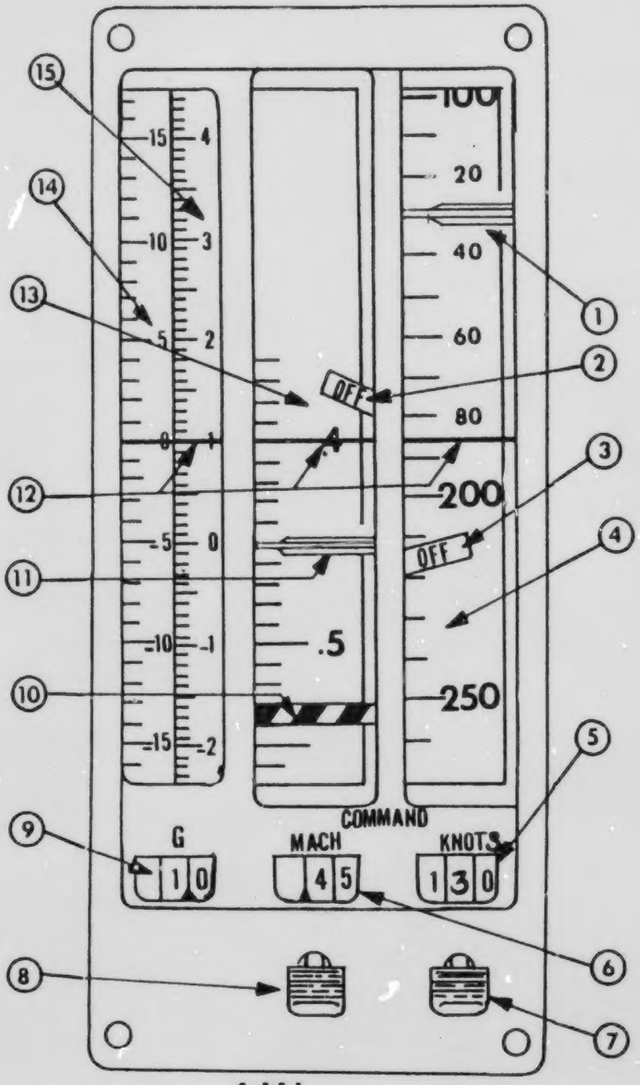
Answer to frame 18: 4

Refer to figure 13 as you study this frame.

The airspeed tape on the right column of the AMI indicates calibrated airspeed. A moving tape is read against a fixed index. The tape is marked in 10-knot increments. It has numerals at each 20-knot increment to 200 knots and 50-knot increments from 200 through 1000 knots. The airspeed tape is driven by electrical signals from the CADC. If there is a signal failure from the CADC, the airspeed warning flag marked OFF will appear across the airspeed tape. The command airspeed marker and a command airspeed counter readout window below the tape show selected command airspeed. Command airspeed is set by the command airspeed slewing switch under the command readout window. The command airspeed marker remains at the top or the bottom of the display column until the selected command airspeed comes into view on the moving tape. At this time, the marker will synchronize with the airspeed tape and move with the reading as shown in the counter readout window. If the pilot desires a continuous digital presentation of his calibrated airspeed, he may place the slewing switch into the detent position. When the slew switch is in detent, the command airspeed marker will align with the fixed index and remain there. The readout window will display a continuous digital readout of calibrated airspeed during flight.

Complete the matching questions using figure 13. Place the numbers from the figure in their proper spaces.

Answer to frame 19: 4


15
14
13
12
11
10
9
8
1
2
3
4
5
6
7
15
10
5
0
-5
-10
-15
4
3
2
1
0
-1
-2
OFF
OFF
.4
.5
100
20
40
60
80
200
250
COMMAND
G
MACH
KNOTS
1 0
4 5
1 3 0

AMI

1. AIRSPEED MACH INDICATOR

Note: Match the numbered items in figure 13 to the statements below. Some numbers may be used more than once while some may not be used at all.

a._____ indicates aircraft true angle of attack.

b._____ indicates "G" loading on the aircraft.

c._____ indicates aircraft Mach number.

d._____ indicates aircraft calibrated airspeed.

e._____ power OFF flag.

f._____ airspeed warning flag.

g._____ indicates command Mach referenced on a tape.

h._____ maximum safe Mach marker.

i. displays a digital readout of command Mach.

j._____ fixed line against which mach tape is read.

k._____ displays command airspeed in a digital readout.

l._____ controls command airspeed counter manually.

m._____ operates command Mach marker.

n._____ displays a digital readout of aircraft "Gs".

o._____ indicates command airspeed referenced on a tape.

Frame 21

Now let's go back and cover the important points of the AMI. First, the overall purpose of the AMI is to display vertical indications of angle-of-attack, "Gs", mach information and calibrated airspeed information.

The angle-of-attack section displays aircraft angle-of-attack information referenced to a fixed index line. The input is α t from the CADC.

The acceleration section displays "G" loading on the aircraft, referenced to a fixed index line. A plus one (+1) "G" is the normal pull of gravity. The input of "Gs" is supplied by the remote accelerometer transmitter.

The mach section displays mach information in the form of aircraft mach number, command mach and maximum safe mach. Inputs are supplied from the CADC and the MSMA.

The airspeed section displays calibrated airspeed from 50 to 1000 knots. The input of Vc comes from the CADC. A command airspeed marker and counter displays command information.

Circle the number of the correct statements below.

1. The purpose of the AMI is to display vertical indications of Vc, M, "G"s, Hp and altitude.

2. The angle-of-attack section receives an input of α t from the CADC.

3. The Mach section displays Mach information in the form of aircraft Mach number, command Mach and maximum safe Mach.

4. The acceleration section indicates aircraft "G" loading.

5. The purpose of the AMI is to display vertical indications of angle-of-attack, "Gs", mach information and calibrated airspeed information.

6. The input α t goes to the angle-of-attack section of the AMI.

7. Inputs to the Mach section are supplied by the MSMA only.

8. The range of the calibrated airspeed tape is 50 to 1000 knots.

9. The AMI displays digital command indications of Mach and calibrated airspeed.

10. The input of the "G" section is supplied by the remote accelerometer transmitter.

Answers to frame 20: a. 14 b. 15 c. 13 d. 4 e. 2

f. 3 g. 11 h. 10 i. 6 j. 12 k. 5 l. 7

m. 8 n. 9 o. 1

1404

Refer to figure 14 as you read this frame.

The altitude-vertical velocity indicator is mounted on the left main instrument panel. The purpose of the Altitude Vertical Velocity Indicator is to display vertical indications of altitude and vertical velocity information. The indicator contains: The vertical velocity indicator, vernier and sensitive altitude tapes and gross altitude information.

The AVVI also has a barometric pressure readout window and barometric pressure set knob. It also has two command altitude markers with a single counter readout window, and a slewing switch for manual selection of the command altitude. The indicator is powered by single-phase, 115V AC, 400 Hz power. It is internally lighted. Electrical signals for operating the moving tapes and markers are supplied by the CADC system. The digits in the readout window are set manually. In the event of CADC failure or AC power failure to the indicator, a spring-loaded warning flag marked OFF will appear across the sensitive altitude tape.

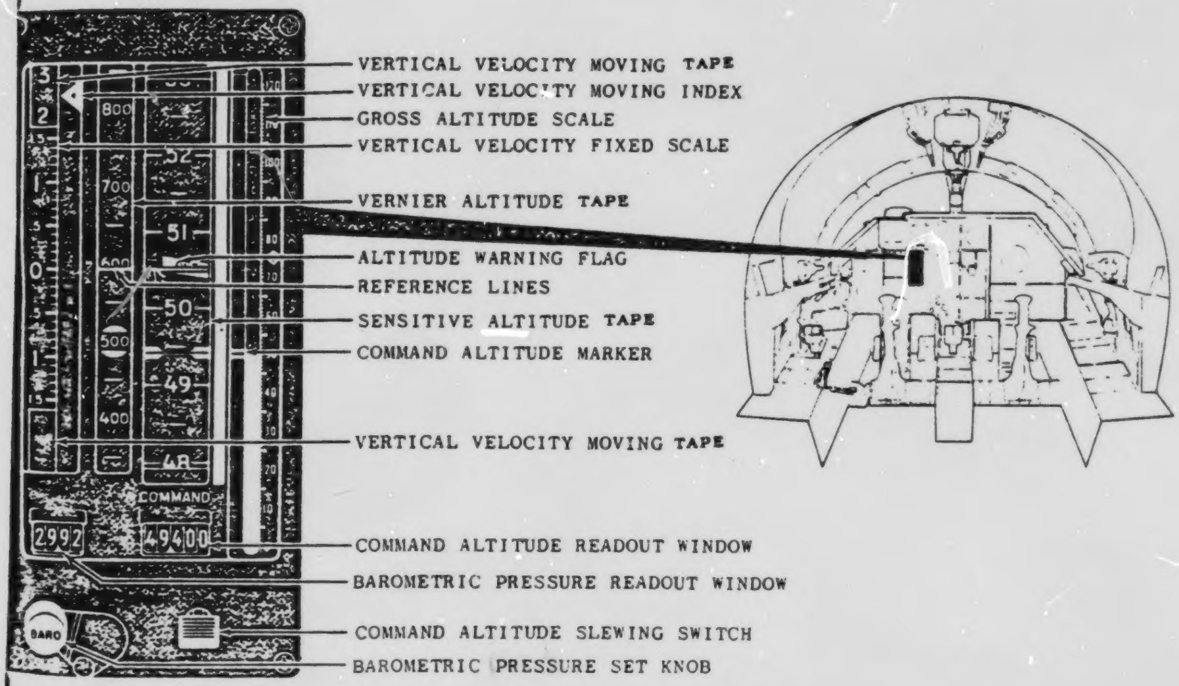

VERTICAL VELOCITY MOVING TAPE
VERTICAL VELOCITY MOVING INDEX
GROSS ALTITUDE SCALE
VERTICAL VELOCITY FIXED SCALE
VERNIER ALTITUDE TAPE
ALTITUDE WARNING FLAG
REFERENCE LINES
SENSITIVE ALTITUDE TAPE
COMMAND ALTITUDE MARKER
VERTICAL VELOCITY MOVING TAPE
COMMAND ALTITUDE READOUT WINDOW
BAROMETRIC PRESSURE READOUT WINDOW
COMMAND ALTITUDE SLEWING SWITCH
BAROMETRIC PRESSURE SET KNOB
COMMAND
2992
49400
BARO
800
700
600
500
400
52
51
50
49
48

Figure 14. Altitude-Vertical Velocity Indicator.

1418

1405

Circle the number that identifies the correct answer.

The purpose of the altitude vertical velocity indicator is to give a vertical presentation of:

1. Altitude and speed information.

2. Altitude and attitude information.

3. Altitude and vertical speed information.

4. Speed and vertical velocity information.

Answers to frame 21: 2, 3, 4, 5, 6, 8, 9 and 10

Refer to figure 14 as you read this frame.

The vertical velocity scales are on the left side of the AVVI. The vertical velocity scales show the rate of climb or dive of the aircraft in feet per minute. The vertical speed rate, up to ± 1500 feet per minute, is shown by an index which moves up or down beside a fixed scale. The scale is marked in 100-foot increments from 0 through ± 1500. Rates in excess of 1500 feet per minute (FPM) are read from a moving tape which comes into view at the appropriate end of the fixed scale. This moving tape is marked in 1000-foot increments from 2000 through 40,000 FPM. The CADC supplies signals for the tape and index.

No Response Required

Answer to frame 22: 3

Frame 24

Still refer to figure 14 as you read this frame.

The altitude scales are located in the center section of the indicator. They show the altitude of the aircraft above or below sea level. Aircraft pressure altitude is read at the fixed index lines across the center of the indicator. The vernier altitude tape is marked in 50-foot increments. The tape has numbered markings every 100 feet from 0 through 1000 feet. The sensitive altitude tape is marked in 500-foot increments. It has numbered markings every 1000 feet from -1000 through 120,000 feet. Signals for the vernier and sensitive altitude tapes are supplied by the CADC. A command altitude marker on the sensitive tape and command altitude readout window under the scale indicate manually selected command altitudes. The marker and digits are manually controlled by the slewing switch under the readout window. Slewing speed is proportional to the movement of the slewing switch from its center position.

Note: The command altitude marker will remain at the top or bottom of the display tape until the selected command altitude comes into view on the altitude scale. At this time, it will synchronize and move with the reading on the scale. The manually selected command altitude is numerically shown at all times in the altitude readout window.

Circle the number(s) that identify the correct statement. Refer to figure 14.

Command altitude is indicated by a:

1. Barometric counter.

2. Single-line marker on the gross altitude scale.

3. Double-line marker on the sensitive altitude tape.

4. Red and black striped marker on the sensitive altitude tape.

Frame 25

The barometric pressure is set into the AVVI by a set knob marked BARO. The knob is on the lower left corner of the indicator. Barometric pressure is displayed in the readout window which is located above the baro set knob. The baro set knob is used to perform an altimeter setting on the AVVI. The altimeter setting is performed on the vertical scale AVVI the same as you performed it using the MA-1 static pressure altimeter.

Circle the number(s) that identify the correct answer.

The barometric pressure set knob is used to set in the

1. command airspeed.
2. altimeter setting.
3. command mach.
4. command altitude.

Answer to frame 24: 3

1409

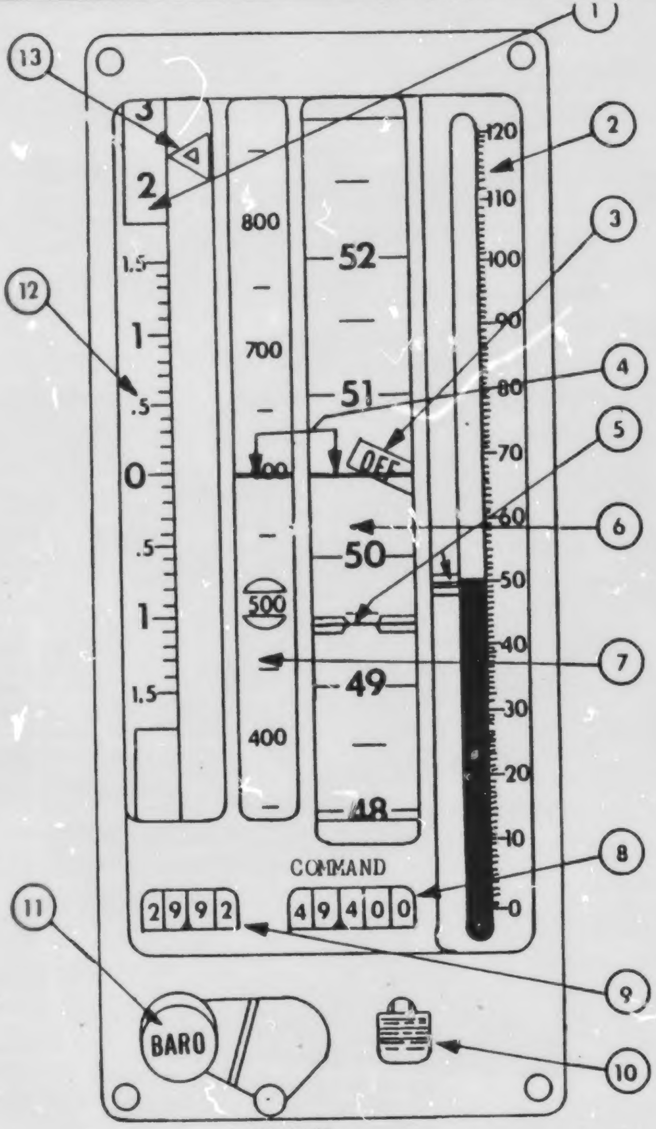
Frame 26

The gross altitude scale (gross altimeter) is located on the right side of the AVVI. It is a thermometer-type altitude index scale. This scale shows the altitude of the aircraft against a gross altitude scale. It is operated by electrical signals from the CADC. The gross altitude scale is marked in thousands of feet. It is numbered every 1000 feet from 0 through 120,000 feet. The gross altitude scale has a command altitude marker similar to the one used with the sensitive altimeter tape. Command altitude on the gross altimeter is shown by a double-line command altitude marker (see figure 14). It is operated along with the command altitude marker on the sensitive altimeter tape.

Using figure 14, complete the matching questions.

Answer to frame 25: 2

1453


1
2
3
4
5
6
7
8
9
10
11
12
13
3
2
1.5
1
.5
0
.5
1
1.5
800
700
500
400
52
51
50
49
48
OFF
120
110
100
90
80
70
60
50
40
30
20
10
0
COMMAND
2992
49400
BARO

AVVI

Figure 15.

1. ALTITUDE VERTICAL VELOCITY INDICATOR

Note: Match the numbered items in figure 15 to the statements below. Some numbers may be used more than once while some may not be used at all.

a.______ controls command altitude markers.

b.______ should display existing sea level pressure.

c.______ movable reference for the vertical velocity section.

d.______ fixed scale, gross altitude.

e.______ indicates rate of climb above 1,500 FPM.

f.______ reference lines for sensitive altitude.

g.______ vernier altitude tape.

h.______ altitude warning flag.

i.______ sensitive altitude tape.

j.______ displays a digital readout of command altitude.

k.______ used to correct for changes in local barometric pressure.

l.______ indicates command altitude against the tapes.

m.______ fixed scale for vertical velocity.

Frame 27

Review:

Statements 1 through 10 are completion-type questions. Circle the correct answer to the following statements. Some statements have more than one correct answer.

1. The AMI indicates

   a. "G" forces.

   b. calibrated airspeed.

   c. vertical velocity.

   d. minimum safe speed.

2. The angle-of-attack tape

   a. receives an α T signal from the computer.

   b. furnishes the pilot with approach information.

   c. furnishes the pilot with altitude information.

   d. receives an Hp signal from the computer.

3. "G" forces are displayed

   a. on a moving tape.

   b. on a fixed scale.

   c. as a command indication.

   d. on a counter.

4. When switch number 8 in figure 13 is depressed, the

   a. command Mach marker is put in motion.

   b. Mach safe marker is put in motion.

   c. Mach counter will rotate.

   d. Mach tape will be put in motion.

5. The command markers and digital readouts

    a. are positioned manually.

    b. operate only in the data link mode.

    c. must always read the same.

    d. can be positioned only by a switch.

6. The Mach safe marker

    a. receives its signal from the CADC.

    b. receives its signal from the MSMA.

    c. is read against the lubber line.

    d. is prevented from driving beyond the field of view by a synchro.

7. The signal for the vertical velocity section

    a. controls item 11 in figure 15.

    b. is cut out in the data link mode.

    c. comes from the central air data computer.

    d. is sent through the altitude vertical speed amplifier.

8. The sensitive altitude tape

    a. is read against the fixed index line.

    b. gets a signal from the CADC.

    c. is ground controlled in the data link mode.

    d. is controlled by 9 in figure 15 in the manual mode.

9. The AVVI indicates

    a. vertical velocity.

    b. angle-of-attack.

    c. target altitude.

    d. distance to target.

10. The gross altitude section

   a. operates only in the data link mode.

   b. furnishes target altitude information.

   c. furnishes distance to target information.

   d. indicates aircraft altitude.

After you have completed the above questions and know how the vertical scale flight instruments work, proceed to section "C" of this programmed text. If you have any trouble understanding the operation of the indicators, ask your station instructor for help.

Answers to frame 26: a. 10 b. 9 c. 13 d. 2 e. 1

f. 4 g. 7 h. 3 i. 6 j. 8 k. 11 l. 5

m. 12

Answers to frame 27: 1. a & b 2. a & b 3. a & d 4. a & c

5. a & d 6. b 7. c & d 8. a & b 9. a 10. d

APPRAISAL

SECTION C

INSTRUCTIONS

In this section of the PT you will be concerned with tracing various CADC system signals. You will receive step by step guidance in tracing simplified circuits. After you are able to trace the simplified circuit, you will be asked to trace the same signal on the electrical schematic in the handout on vertical scale flight instruments. You may then check the circuit you traced with the correct answer shown at the bottom of each frame.

> Note: Ask your instructor for the above handout at this time as you will need to refer to it as you complete Section C of this programmed text.

Frame 28

The first signal you will trace is the pressure altitude (Hp) signal. This signal is sensed at the pitot-static tube and transmitted to the CADC. Two aneroids inside the Psi transducer measure the static pressure.

Connected to the aneroids is the rotor of a microsyn (synchro). As the aneroids expand or contract, the microsyn generates an electrical Hp signal. This signal is amplified and sent to a motor generator. The mechanical Hp output from the motor generator drives a computing mechanism. The output of the computing mechanism is a correct Hp signal and is applied to several output devices. Trace the Hp signal on the simplified diagram (figure 16) that follows. After you have completed tracing the signal, locate the Psi section in figure 1 of the CADC block diagram shown in the vertical scale flight instrument handout.

Trace the Hp signal on the simplified schematic; no additional response is required.

Frame 29

Copy the list of Hp and Log Ps outputs listed in this frame onto your CADC schematic. This information will be an aid to you when you are troubleshooting the CADC system. The following list of outputs are applied to various systems within the aircraft.

1. 1A - altitude tape on AVVI and monitor synchro signal.
2. 7A - altitude hold autopilot system.
3. 23A - landing gear warning system.
4. 39A, 40A, 10A, and 41A - MSMA.

No Response Required

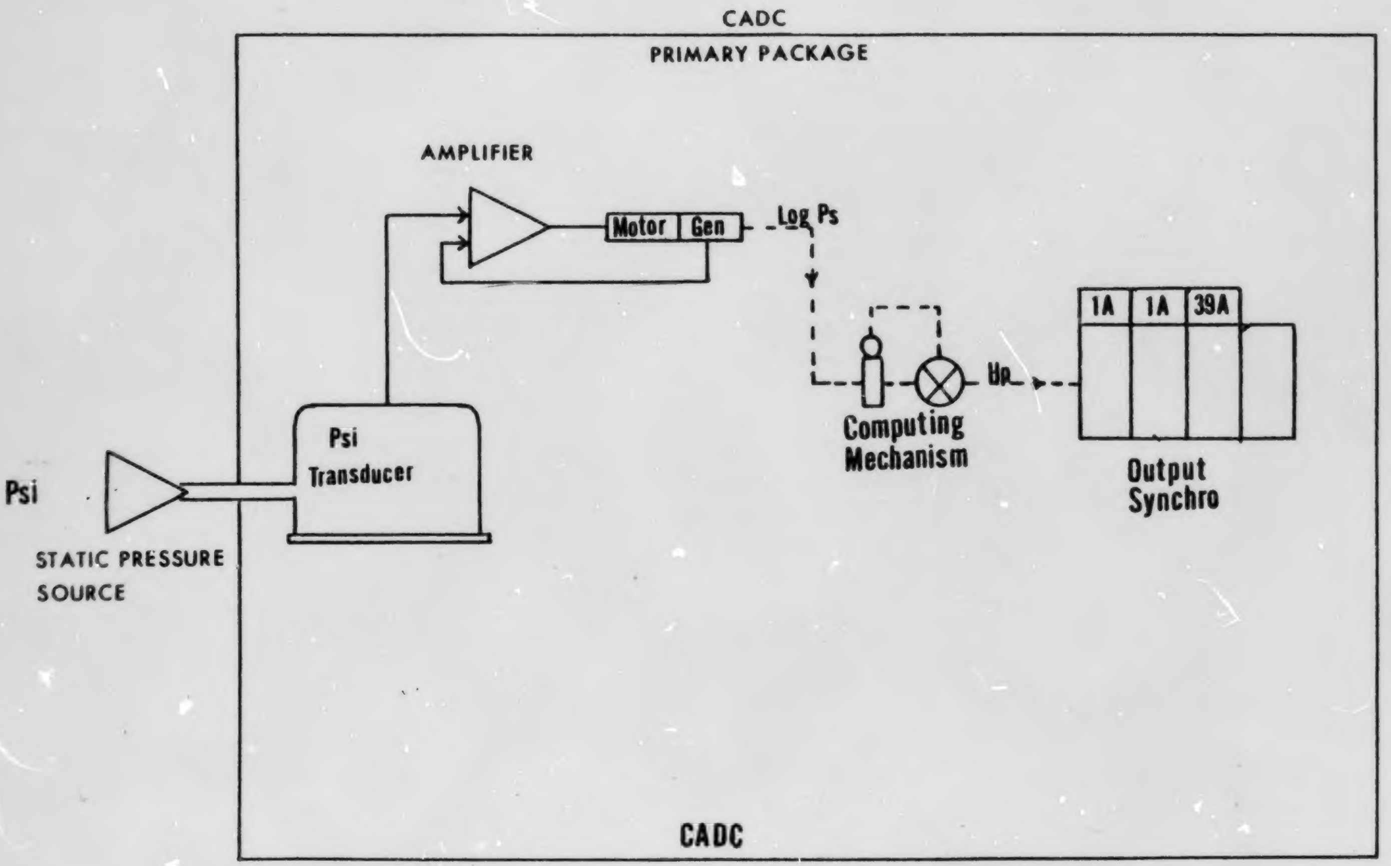

CADC
PRIMARY PACKAGE
AMPLIFIER
Motor
Gen
Log Ps
1A
1A
39A
Psi
Psi
Transducer
Computing
Mechanism
Hp
Output
Synchro
STATIC PRESSURE
SOURCE
CADC

Figure 16.

14/6

1461

1462

1417

Frame 30

Using the simplified schematic (figure 17), trace the Hp signal from the CADC output 1A to the altitude tape. The synchro transmitters, CX12 and CX14, are driven by the Hp shaft in the CADC. The output from the transmitters is applied to the course and fine synchro receivers, CD 901 and CD 903, in the AVVI. The output from the receivers is sent to the control transformers, CT 701 and CT 702. After the signal is coupled through the transformers it is amplified by the altitude vertical velocity amplifier. From the amplifier it is applied to the variable phase of the motor MG 701. The generator, which is driven by the motor, generates a feedback signal that is 180° out-of-phase with the input signal to the amplifier. This signal is coupled back to the amplifier to prevent oscillation and overtravel of the altitude tape. The altitude tape is mechanically connected to the motor-generator. When an altitude change occurs, the motor drives the altitude tape to the new altitude. To complete the servo loop there must be some method of nulling the signal. This is accomplished by the motor turning the rotors of the control transformers and the generator which nulls the signal. The synchro and motor-generator all arrive at null at the same time.

After you have traced the Hp signal on the simplified schematic, turn to figure 2 in the vertical scale flight instruments handout. Locate the CADC output 1A and trace the Hp signal through the schematic to the altitude tape. The altitude signal will be colored ORANGE.

After you have traced the pressure altitude signal in the above handout, check the accuracy of your work with the correct answer shown in figure 18 of this PT.

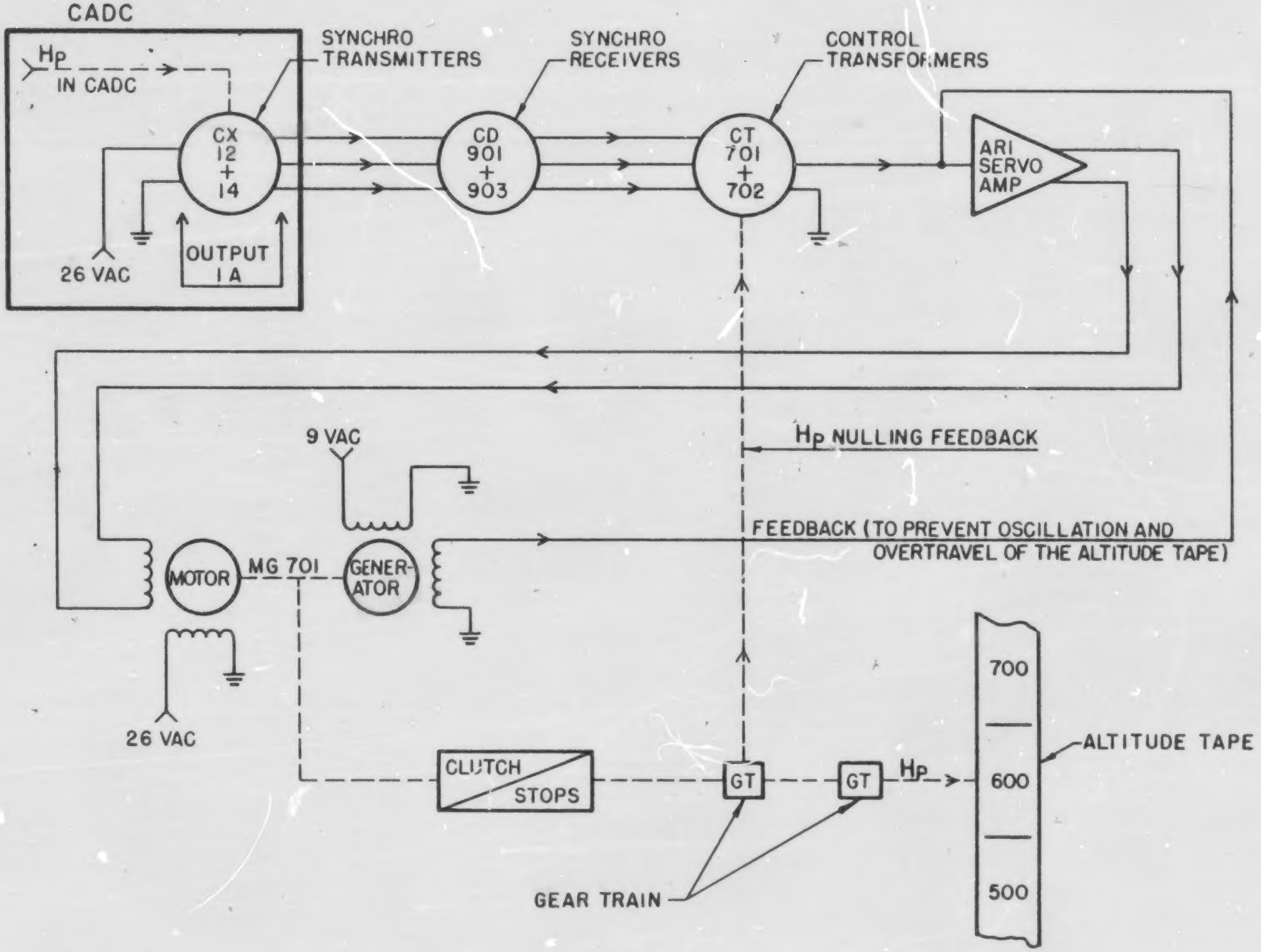

CADC
H_P IN CADC
SYNCHRO TRANSMITTERS
CX 12 + 14
26 VAC
OUTPUT 1 A
SYNCHRO RECEIVERS
CD 901 + 903
CONTROL TRANSFORMERS
CT 701 + 702
ARI SERVO AMP
H_P NULLING FEEDBACK
9 VAC
FEEDBACK (TO PREVENT OSCILLATION AND OVERTRAVEL OF THE ALTITUDE TAPE)
MOTOR
MG 701
GENERATOR
26 VAC
CLUTCH
STOPS
GT
GT
H_P
GEAR TRAIN
700
600
500
ALTITUDE TAPE

Figure 17.

14/8

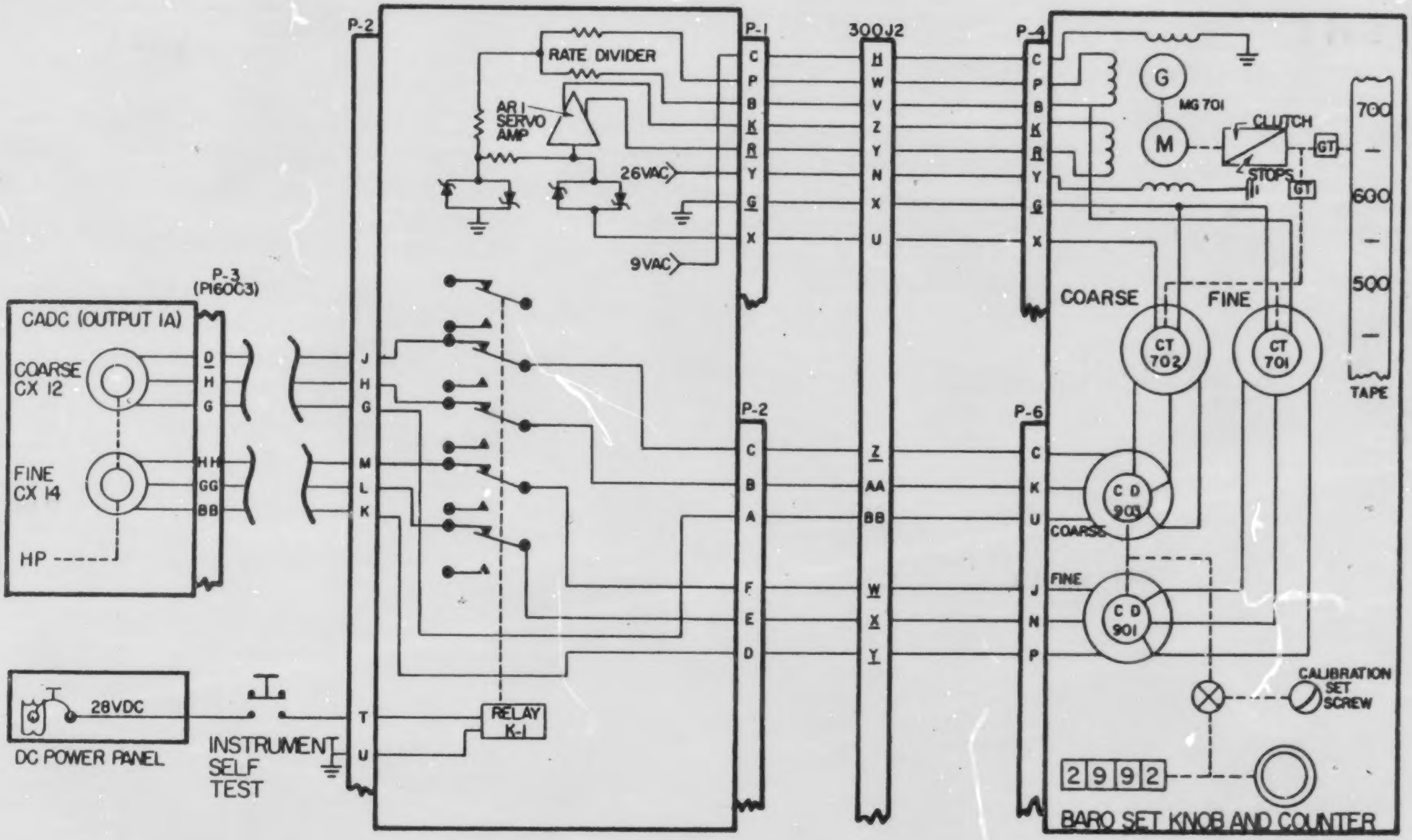

P-2
RATE DIVIDER
AR 1
SERVO
AMP
26VAC
9VAC
P-1
C
P
B
K
R
Y
G
X
300J2
H
W
V
Z
Y
N
X
U
P-4
G
MG 701
M
CLUTCH
STOPS
GT
700
600
500
TAPE
COARSE
FINE
CT
702
CT
701
P-3
(P160C3)
CADC (OUTPUT 1A)
COARSE
CX 12
FINE
CX 14
HP
D
H
G
HH
GG
BB
J
H
G
M
L
K
P-2
C
B
A
F
E
D
Z
AA
BB
W
X
Y
P-6
C
K
U
J
N
P
C D
903
COARSE
FINE
C D
901
CALIBRATION
SET
SCREW
28VDC
DC POWER PANEL
INSTRUMENT
SELF
TEST
T
U
RELAY
K-1
2992
BARO SET KNOB AND COUNTER

Figure 18.

Frame 31

Using the simplified schematic (figure 19) trace the vertical velocity ($H\dot{p}$) signal from the CADC output 2A to the $H\dot{p}$ tape. The $H\dot{p}$ output from the computer is coupled by T-2 to the phasing network T-3 and T-4. R-1 is the zero adjust resistor. From R-1 the signal is applied to the QUAD REJECTION AMPLIFIER AR-5. The QUAD REJ AMP also receives a feedback signal from the generator. The feedback signal is coupled across R-1201, the damping adjust pot. After the QUAD REJ AMP allows the correct signal to pass, it is amplified by AR-4 and applied to the motor. The motor turns and drives the generator, the $H\dot{p}$ tape and the wiper arm of R-2 which nulls the $H\dot{p}$ signal and completes the servo loop.

After you have traced the Hp signal on the simplified schematic, turn to figure 2 in the vertical scale flight instruments handout. Locate the CADC output 2A and trace the $H\dot{p}$ signal through the schematic to the $H\dot{p}$ tape. The vertical velocity signal will be colored DARK GREEN.

After you have traced the vertical velocity signal in the above handout, check the accuracy of your work with the correct answer shown in figure 20 of this PT.

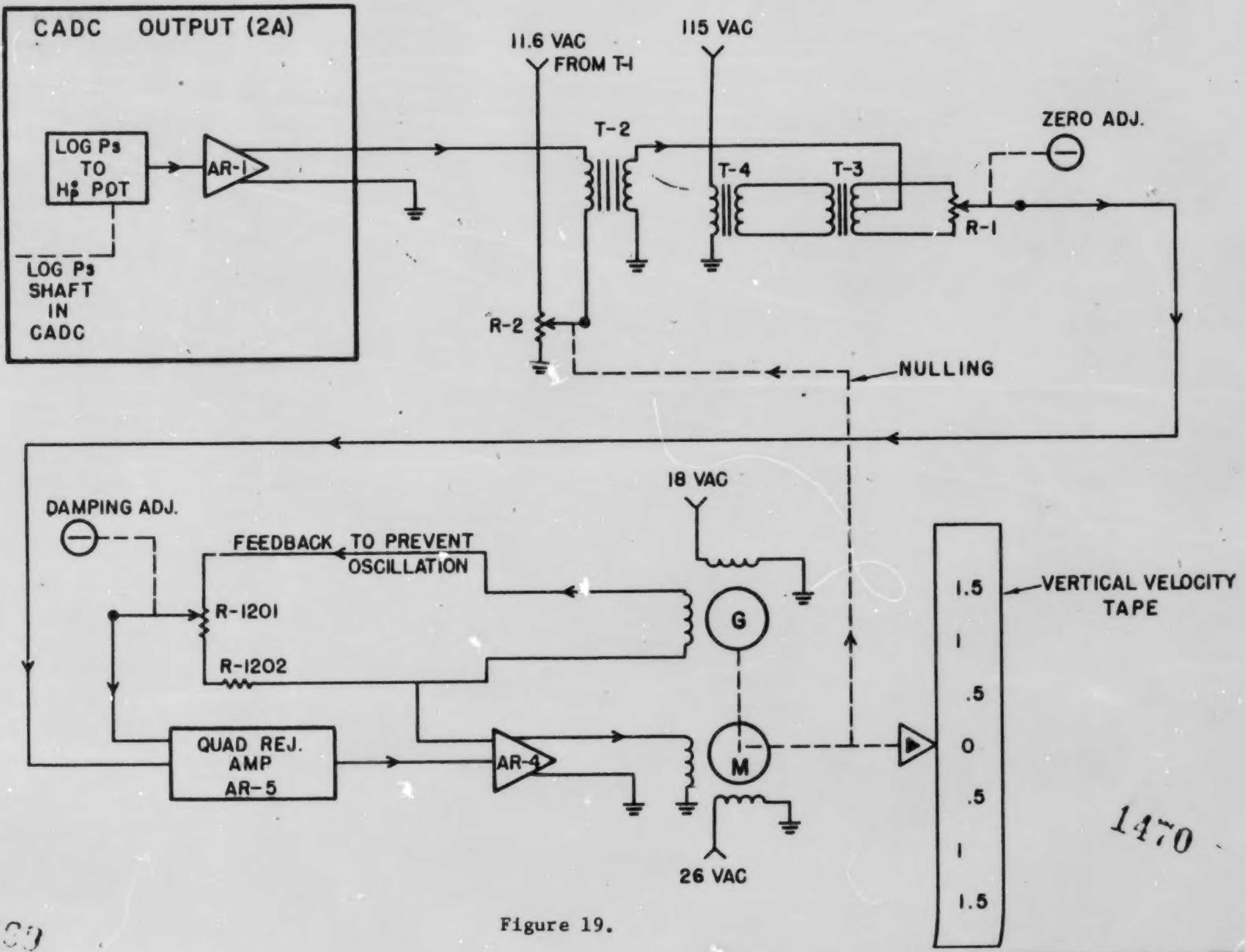

CADC OUTPUT (2A)
LOG Ps TO Hs POT
AR-1
LOG Ps SHAFT IN CADC
11.6 VAC FROM T-1
115 VAC
T-2
T-4
T-3
ZERO ADJ.
R-1
R-2
NULLING
18 VAC
DAMPING ADJ.
FEEDBACK TO PREVENT OSCILLATION
R-1201
R-1202
G
M
QUAD REJ. AMP AR-5
AR-4
26 VAC
1.5
1
.5
0
.5
1
1.5
VERTICAL VELOCITY TAPE

Figure 19.

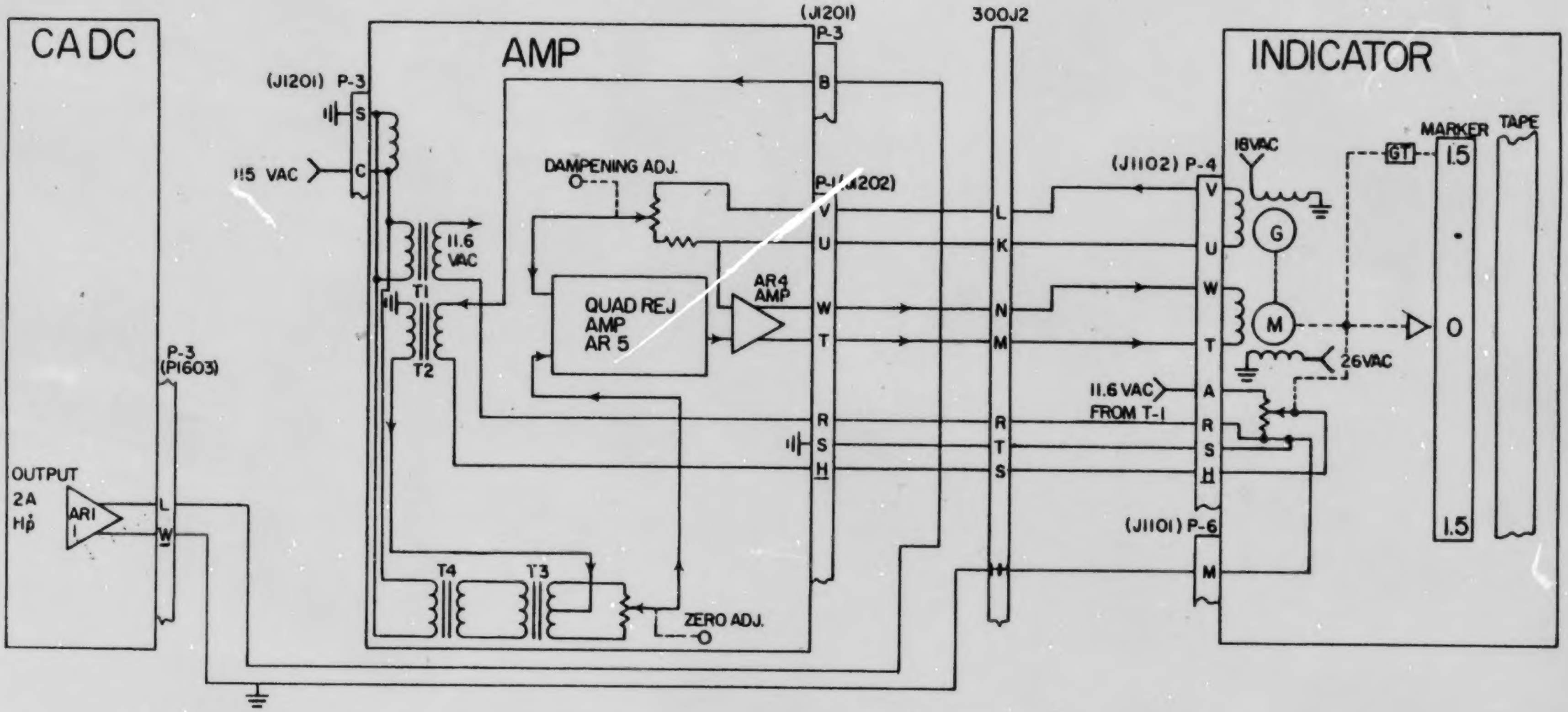

CADC
AMP
INDICATOR
(J1201)
P-3
300J2
(J1201) P-3
S
C
115 VAC
B
DAMPENING ADJ.
P-1(J1202)
V
U
W
T
R
S
H
11.6 VAC
T1
T2
QUAD REJ AMP AR 5
AR4 AMP
T4
T3
ZERO ADJ.
P-3 (P1603)
OUTPUT 2A Hṗ
AR1 1
L
W
L
K
N
M
R
T
S
(J1102) P-4
V
U
W
T
A
R
S
H
18VAC
G
M
26VAC
11.6 VAC FROM T-1
(J1101) P-6
M
GT
MARKER
TAPE
1.5
0
1.5

Figure 20.

1471

1472

1422

1423

Frame 32

The mach signal originates in the Pt transducer (figure 21) inside the CADC. The Pt transducer receives pitot and static pressure from the pitot-static tube. The airspeed diaphragm inside the Pt transducer, expands and contracts with changes in either aircraft airspeed or altitude. The airspeed diaphragm is mechanically connected to the rotor of a synchro inside the Pt transducer. When the diaphragm expands or contracts, the rotor of the synchro is turned creating the mach signal. The Mach signal is amplified by AR-5 and sent to the motor-generator. The mechanical shaft rotation of the motor is connected to: (1) the Pt transducer for nulling the servoloop; (2) the self-test synchro to keep it in the correct phase; (3) differential number 5 where log Qc and log Ps are mixed. The output of differential #5 is log Qc/Ps and is applied to the Qc/Ps vernistat. The output of the Qc/Ps vernistat is an electrical signal equal to Mach. The electrical mach signal is amplified by AR-6 and applied to the motor-generator MG-3. Nulling is accomplished by a feedback from the mach vernistat (pot). The generator sends a signal back to the amplifier to prevent oscillation of the mach tape. The mechanical output of the motor is connected to the various output synchros and pots. Synchro output 3A is the mach output from the computer to the airspeed-mach indicator.

Note: You may have noticed a slight reference to the use of the log prior to this frame. This term, if you are not familiar with it, is a methematical function used to denote extremely large and small numbers. For the purpose of transferring large signals, like Qc, and small signals like P_s, these values are transformed to logarithmic terms.

Trace the Mach signal on the simplified schematic, figure 21. After you have traced the Mach signal on the simplified schematic, locate the computer schematic in the vertical scale flight instruments handout. Trace the Mach signal on the computer schematic. If you have any questions on how the Mach signal originates, ask your instructor.

1473

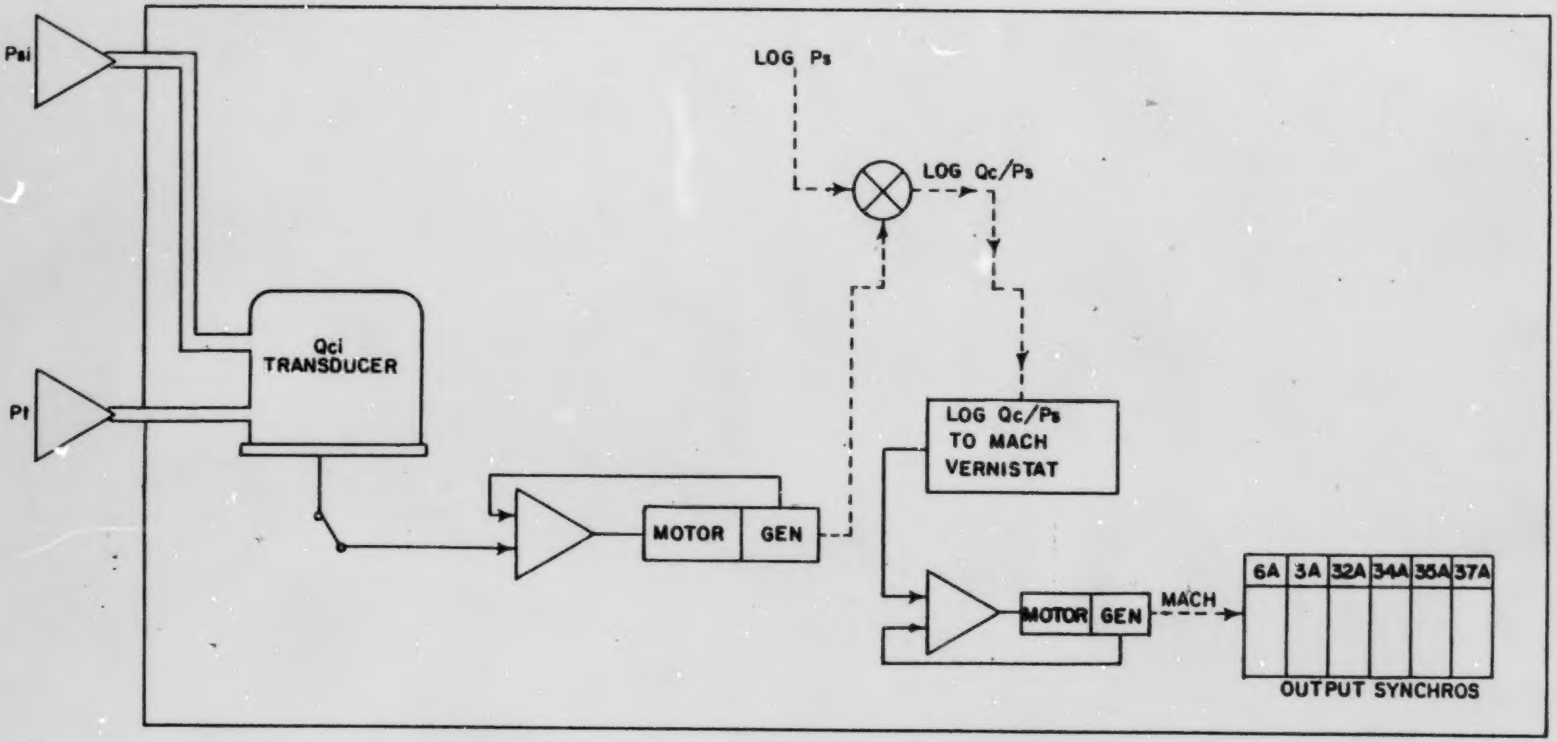

Psi
Pt
Qci TRANSDUCER
MOTOR
GEN
LOG Ps
LOG Qc/Ps
LOG Qc/Ps TO MACH VERNISTAT
MOTOR
GEN
MACH
6A
3A
32A
34A
35A
37A
OUTPUT SYNCHROS

Figure 21.

Frame 33

The following list of numbered output signals are from the CADC. Locate the computer schematic, figure 1, in the vertical scale flight instruments handout. This listing is below the Primary and Secondary package schematic.

Note: These output numbers are references only.

1. Output 4A - calibrated airspeed - used in AMI for airspeed tape.

2. Output 5A - α T - used in AMI for angle-of-attack tape.

3. Output 6A - Mach signal - used for Mach hold in autopilot system.

4. Outputs 9A, 12A, and 36A are spares.

5. Output 10A and 38A - M signal - used in MSMA.

6. Output 21A - α T signal - used in the terrain following radar system (TFR).

7. Output 24A - calibrated airspeed (Vc) - used in the landing gear warning system.

8. Output 26A - Vt signal - operates the true airspeed indicator.

9. Outputs 27A, 28A, and 29A - α T signal - used by angle-of-attack indexer lites.

10. Output 30A - Hp signal - used by the flight director computer (FDC).

11. Output 32A - M signal - used by the engine oil cooling and spike control.

12. Output 33A thru 35A - M signal - used by the engine translating cowl.

13. Output 42A - Tfat signal - used by the MSMA.

14. Output 43A - Vt signal - used by the Terrain Following Radar.

15. Output 44A - Tfat signal - used by the ram air exit control.

Note: The outputs for various air data computers will vary depending on the type of aircraft in which they are installed. You should refer to the applicable aircraft TO to determine the computer outputs for your specific type aircraft.

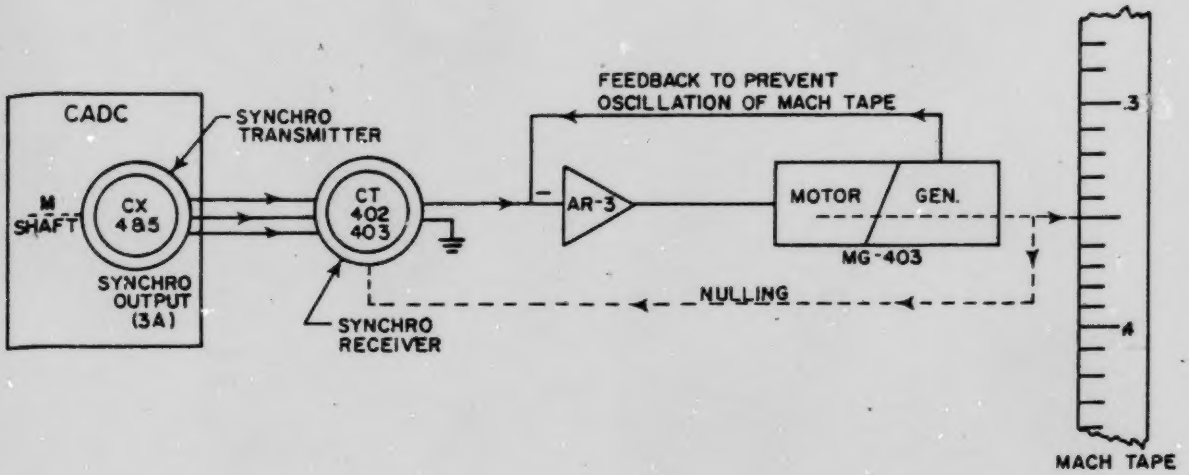

CADC
SYNCHRO TRANSMITTER
M SHAFT
CX 485
SYNCHRO OUTPUT (3A)
CT 402 403
SYNCHRO RECEIVER
FEEDBACK TO PREVENT OSCILLATION OF MACH TAPE
AR-3
MOTOR
GEN.
MG-403
NULLING
.3
.4
MACH TAPE

Figure 22.

Using the simplified schematic (figure 22), trace the Mach signal from the CADC output 3A to the mach tape. The two synchro-transmitters CX4 and 5 are driven by the mach shaft rotation in the computer. The outputs from the coarse and fine transmitters are applied to synchroreceivers CT402 and CT403. From the receivers, the signal is amplified and applied to the motor-generator MG403. Servoloop nulling is accomplished by repositioning the rotors of CT402 and CT403. The mach tape is positioned by the motor and will move with changes in aircraft mach.

After you have traced the Mach signal on the simplified schematic, turn to figure 4 in the vertical scale flight instruments handout. Locate the CADC output 3A and trace the Mach signal through the schematic to the Mach tape. Check the accuracy of your work with the correct answer shown in figure 23 of this PT. The Mach signal will be colored PINK.

1427

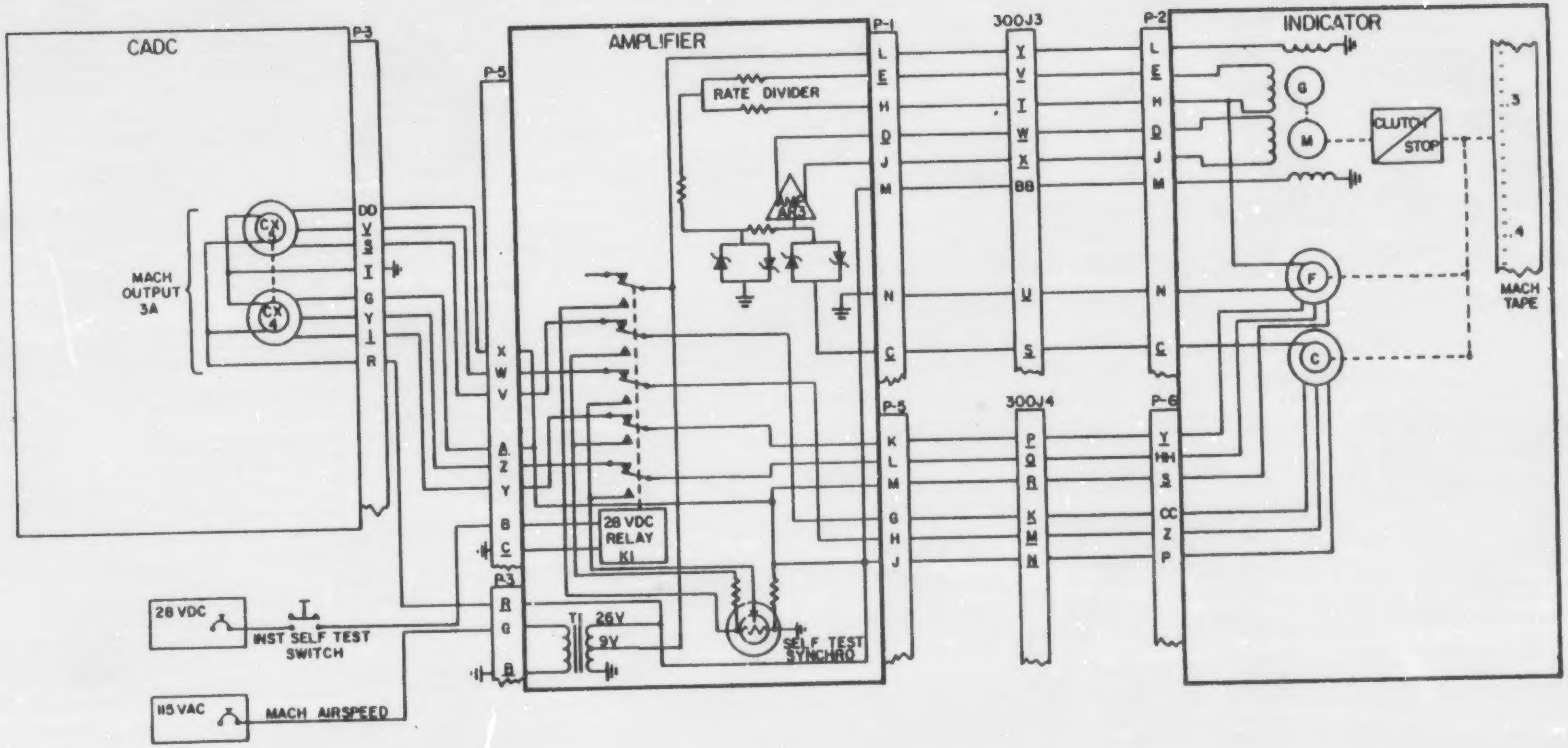

CADC
P-3
MACH OUTPUT 3A
CX 3
CX 4
AMPLIFIER
P-5
RATE DIVIDER
AR3
28 VDC RELAY K1
T1
26V
9V
SELF TEST SYNCHRO
P-1
300J3
300J4
P-2
P-6
INDICATOR
G
M
CLUTCH STOP
F
C
3
4
MACH TAPE
28 VDC
INST SELF TEST SWITCH
115 VAC
MACH AIRSPEED

Figure 23.

1478

1479

Frame 35

So far in your study of the CADC circuit analysis, you have traced the altitude, vertical velocity, and mach signals. The three signals were used to operate servoloops. The calibrated airspeed (Vc) also operates a servoloop. It consists of transmitters (CX9 and 10), receivers (CT501 and 502), an amplifier, motor-generator, and a method of nulling the loop. Trace the Vc signal on the simplified schematic (figure 24).

After you have traced the Vc signal on the simplified schematic, turn to figure 5 in the vertical scale flight instruments handout. Locate the CADC output 4A and trace the Vc signal through the schematic to the airspeed tape. The airspeed signal will be colored PURPLE.

Check the accuracy of your work with the correct answer shown in figure 25.

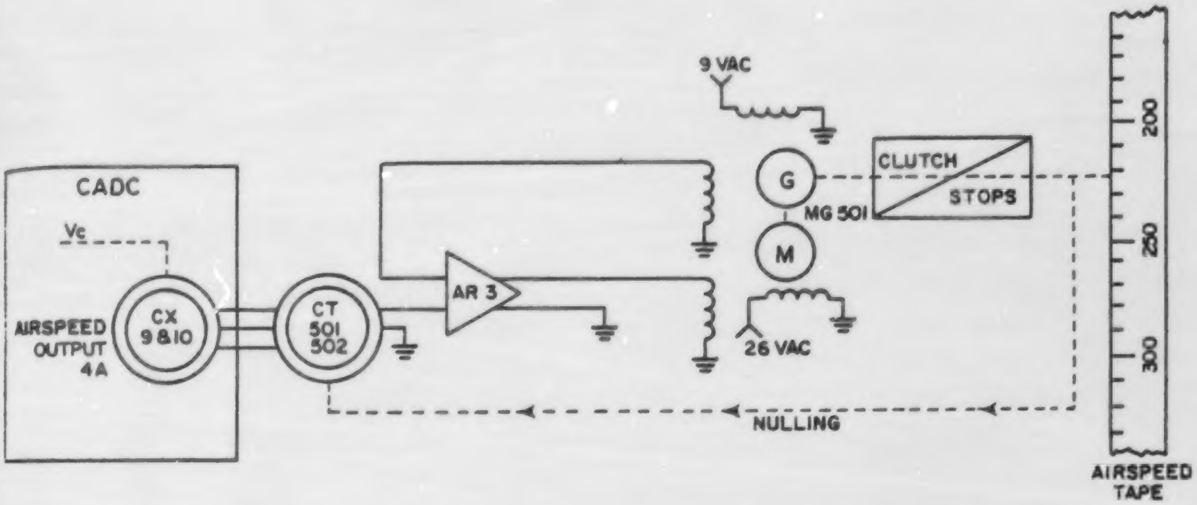

9 VAC
CADC
Vc
AIRSPEED OUTPUT 4A
CX 9&10
CT 501 502
AR 3
G
MG 501
M
26 VAC
CLUTCH
STOPS
200
250
300
NULLING
AIRSPEED TAPE

Figure 24.

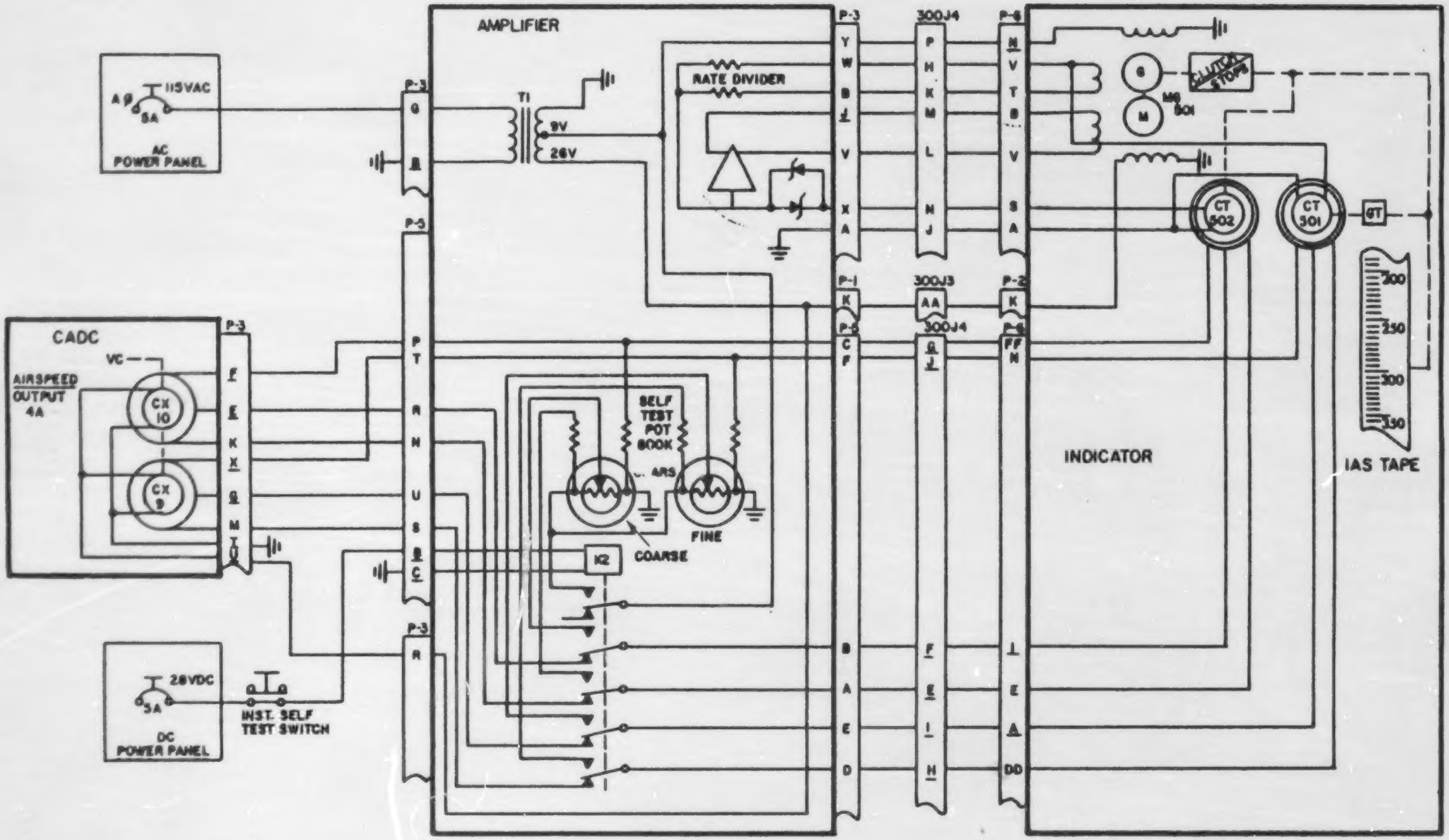

AMPLIFIER
AC POWER PANEL
115VAC
5A
T1
9V
26V
RATE DIVIDER
P-3
P-5
P-1
P-2
P-6
300J4
300J3
CADC
VC
AIRSPEED OUTPUT 4A
CX 10
CX 9
SELF TEST POT BOOK
COARSE
FINE
K2
DC POWER PANEL
28VDC
INST. SELF TEST SWITCH
CLUTCH STOPS
MG 501
CT 502
CT 501
GT
INDICATOR
IAS TAPE
200
250
300
350

Figure 25.

Frame 36

The next signal to be traced is the angle-of-attack signal. The α i signal originates at the AOA probe. It is transmitted to the CADC where it is changed to α T. Output 5A is the α T output from the CADC. α T is transmitted from CX3 in the CADC to CT301 in the AMI. From the synchro receiver CT301, it is amplified and sent to the motor-generator MG301. The mechanical output of the motor positions the AOA tape. Nulling is accomplished by a mechanical connection from the motor to the rotor of CT301. Use the simplified schematic (figure 26) and trace the AO signal from the AOA probe to the AOA tape.

After you have traced the AOA signal on the simplified schematic, turn to figure 3 in the vertical scale flight instruments handout. Locate the CADC output 5A and trace the α T signal through the schematic to the α T tape. The angle-of-attack signal is colored BROWN.

Check the accuracy of your work with the correct answer shown in figure 27 of this PT.

1431

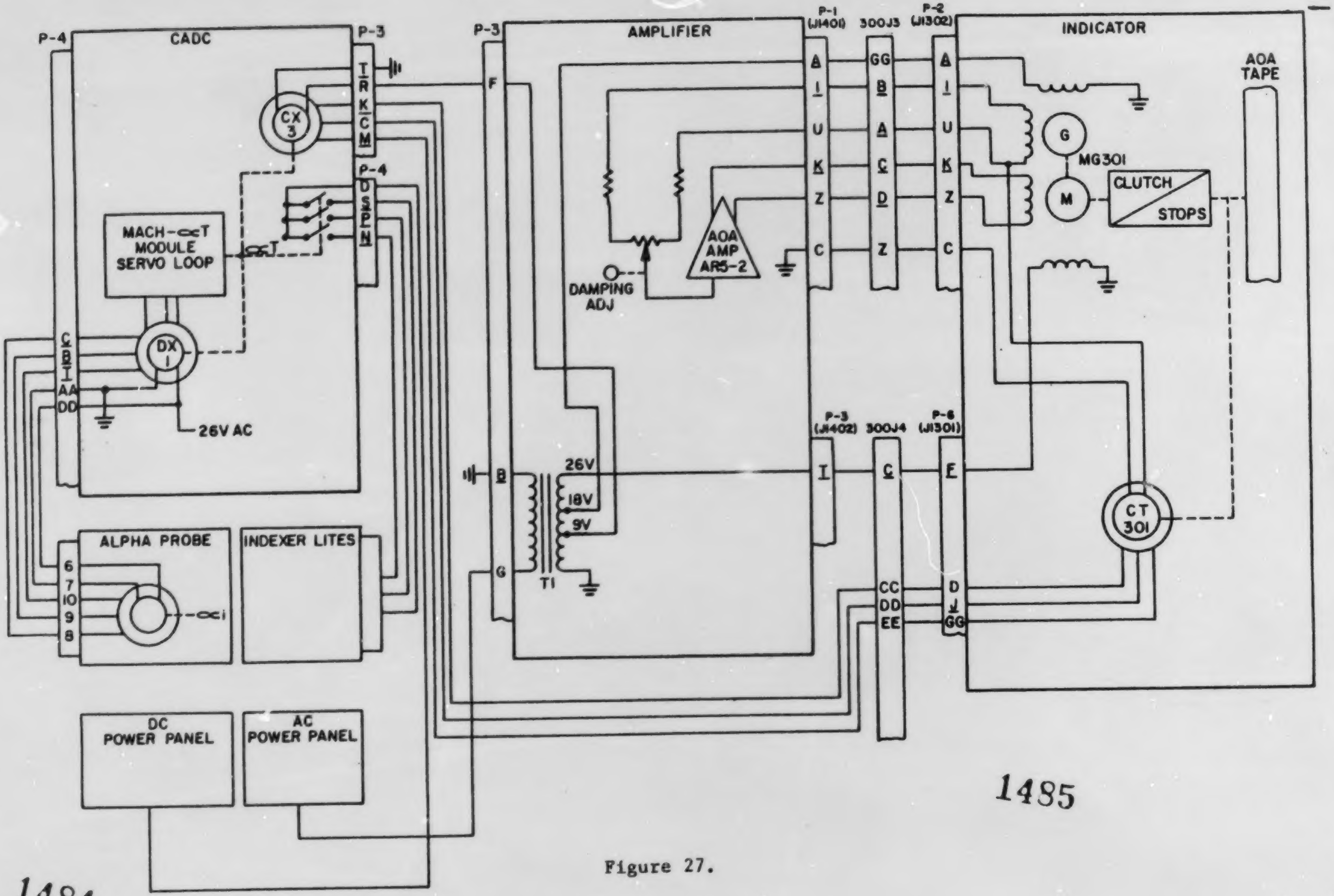

CADC
P-4
P-3
T
R
K
C
M
CX 3
P-4
D
S
P
N
MACH-∝T MODULE SERVO LOOP
∝T
DX 1
C
B
I
AA
DD
26V AC
ALPHA PROBE
6
7
10
9
8
∝i
INDEXER LITES
DC POWER PANEL
AC POWER PANEL
P-3
F
B
G
AMPLIFIER
DAMPING ADJ
AOA AMP AR5-2
26V
18V
9V
T1
P-1 (J1401)
A
I
U
K
Z
C
300J3
GG
B
A
C
D
Z
P-2 (J1302)
A
I
U
K
Z
C
P-3 (J1402)
I
300J4
C
CC
DD
EE
P-6 (J1301)
F
D
J
GG
INDICATOR
G
MG301
M
CLUTCH
STOPS
AOA TAPE
CT 301

Figure 27.

1484

1485

Frame 37

The Airspeed Mach Indicator has a display of Maximum Safe Mach (MSM). This display is in the form of a striped marker.

The MSM signal is made up of many different inputs. Referring to the simplified schematic, figure 28, trace the MSM signal to the MSM Marker.

The CADC contains six (6) potentiometers which supply outputs to the MSM Amp. The outputs of the CADC are 38A-Mach, 42A-Tfat, 39A and 40A-Log Ps, 41A and 10A-Log Ps and ⌃. These CADC outputs are sent to the MSM Amp. In this amplifier the signals are computed, compared, amplified and sent to a motor-generator assembly MG-1. The output of MG-1 is mechanically linked to the rotor of a control transformer (CT-1). The MSM signal is then sent to CT401 in the AMI. The output of CT401 is amplified and applied to MG401. The mechanical output of MG401 is connected through a clutch/stop assembly to the MSM marker. Mechanical linkage from the clutch/stop assembly is also connected to CT401 as a means for nulling the signal.

After you have traced the MSM signal on the simplified schematic, turn to figure 4 in the vertical scale flight instruments handout. Locate the CADC outputs of 38A, 42A, 39A, 40A, 41A, and 10A and trace these outputs to the MSM amp. Trace the MSM signal from CT-1 in the MSM amp to the MSM marker. The maximum safe Mach signal is colored DARK YELLOW.

Check the accuracy of your work with the correct answer shown in figure 29 of this PT.

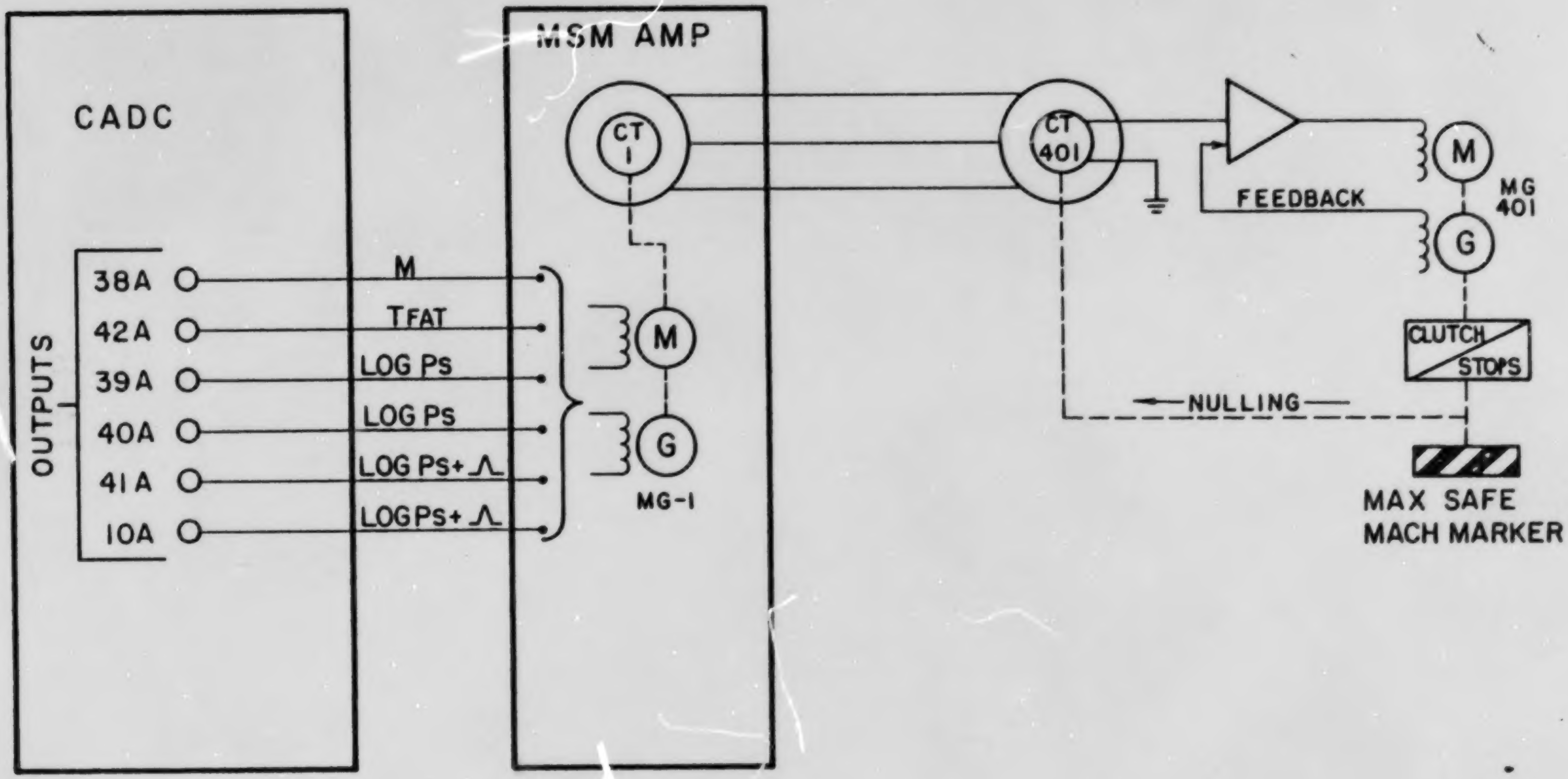

CADC
OUTPUTS
38A
42A
39A
40A
41A
10A
M
TFAT
LOG Ps
LOG Ps
LOG Ps+ ⋀
LOGPs+ ⋀
MSM AMP
CT 1
M
G
MG-1
CT 401
M
G
MG 401
FEEDBACK
CLUTCH
STOPS
NULLING
MAX SAFE
MACH MARKER

Figure 28.

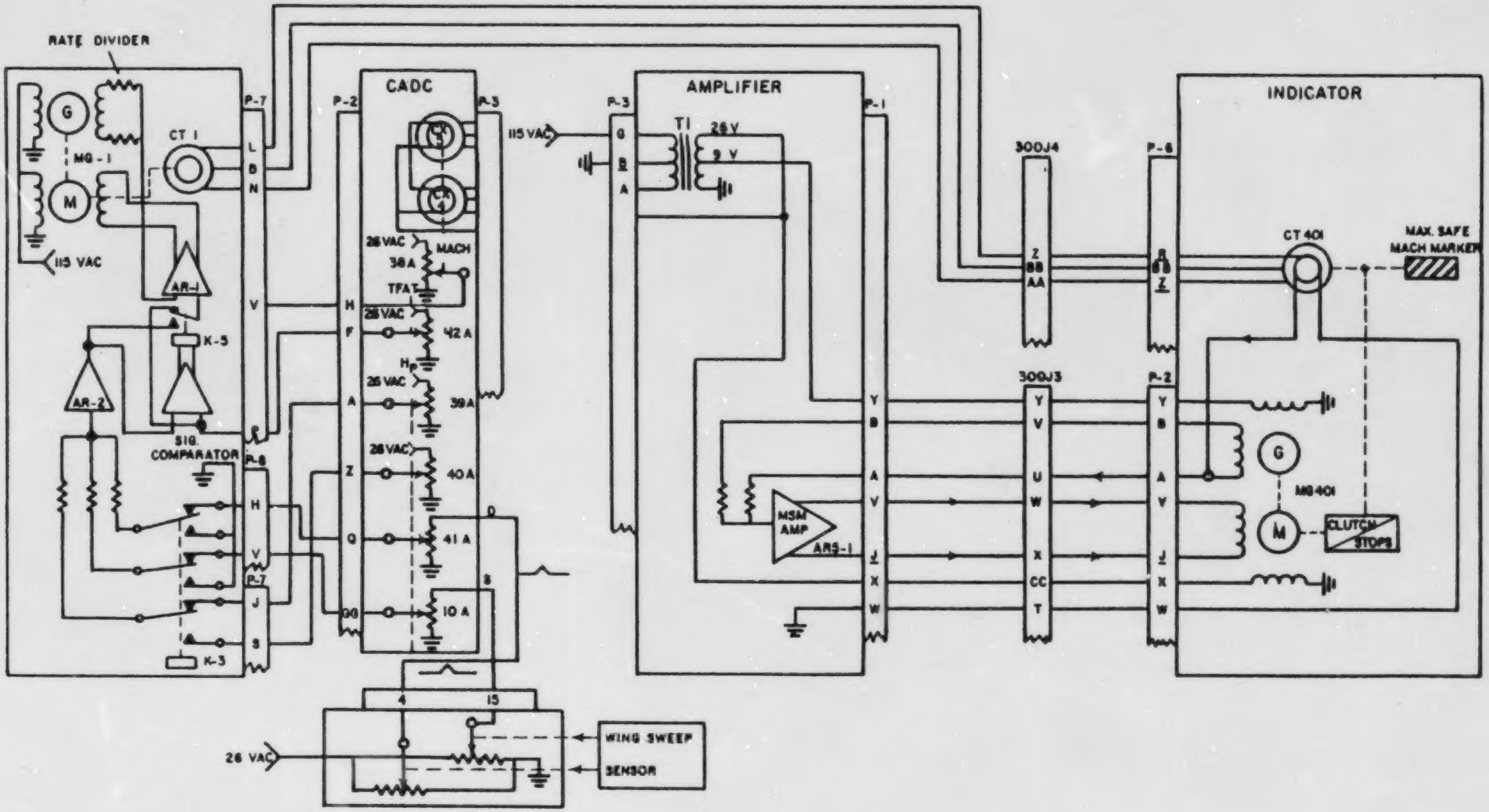

RATE DIVIDER
G
MG-1
M
115 VAC
CT 1
AR-1
K-5
AR-2
SIG. COMPARATOR
K-3
P-7
L
D
N
V
R
P-8
H
V
P-7
J
S
CADC
P-2
P-3
26 VAC
38A
MACH
TFAT
H
F
42A
Hp
A
39A
Z
40A
Q
41A
GG
10A
D
8
4
15
WING SWEEP
SENSOR
26 VAC
AMPLIFIER
115 VAC
G
R
A
T1
26 V
9 V
P-1
Y
B
A
V
J
X
W
MSM AMP
ARS-1
300J4
Z
BB
AA
P-6
300J3
Y
V
U
W
X
CC
T
P-2
INDICATOR
CT 401
MAX. SAFE MACH MARKER
G
MG401
M
CLUTCH STOPS

Figure 29.

Frame 38

Another signal circuit to be traced is the accelerometer signal circuit. Locate the vertical accelerometer in figure 30. A synchro output of vertical acceleration ("G"s) is sent to the AMI (CT302). The output of CT302 is sent to the amplifier through the rate divider to the G amp, AR4-2, where the signal is amplified in order to drive MG302 in the AMI. The mechanical output of MG302 is sent through the clutch/stop assembly to the G tape and counter. A nulling mechanical output is applied to the rotor of CT302.

Now that you have traced the accelerometer signal in figure 30 of this PT, refer to figure 3 in the vertical scale flight instruments handout. Locate the vertical accelerometer and trace the G circuit to the G tape. The "G" signal is colored LIGHT RED.

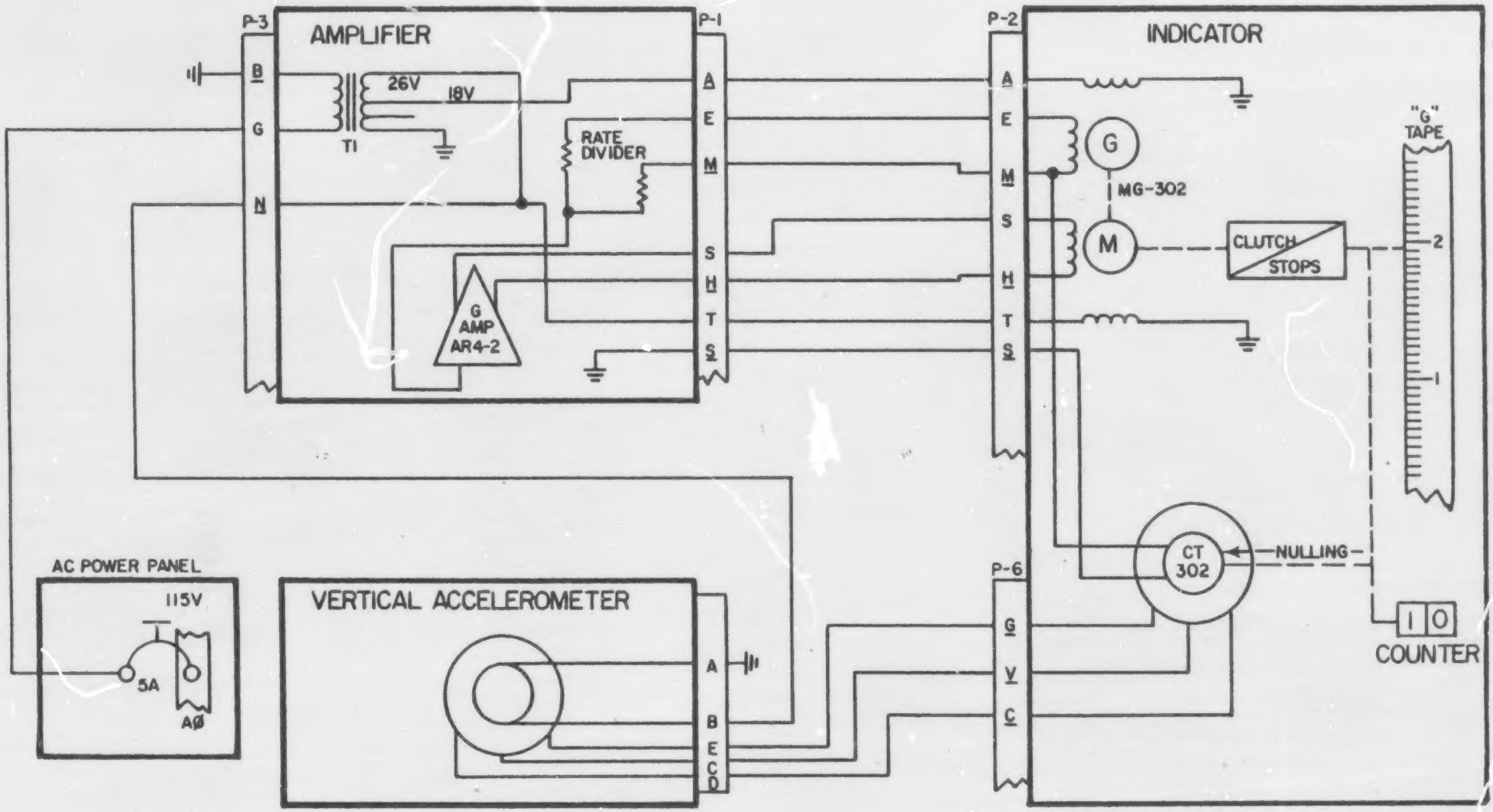

P-3
AMPLIFIER
P-1
P-2
INDICATOR
B
G
N
26V
18V
T1
RATE DIVIDER
G AMP AR4-2
A
E
M
S
H
T
S
G
MG-302
M
CLUTCH STOPS
"G" TAPE
2
1
CT 302
NULLING
COUNTER
I 0
P-6
G
V
C
AC POWER PANEL
115V
5A
AØ
VERTICAL ACCELEROMETER
A
B
E
C
D

Figure 30.

1436

Frame 39

This frame explains the command marker/counter circuits. Referring back to section B of this programmed text, the operation of the command markers and counters was explained. The altitude, airspeed, and Mach command marker/counter indications are all basically the same. The altitude command marker/counter circuit will be discussed in this frame, but all command marker/counter circuits are identical (Mach, airspeed, and altitude).

Using the simplified schematic, figure 31, trace the command altitude signal circuit. Transformer T-2 supplies 26V AC for power to the Command Alt. circuit. The slew switch controls the position of contacts 1 and 3 through mechanical linkage. Contact 3 controls the direction of motor rotation and in turn, movement of the command marker/counter assembly. Contact 1 controls the speed of the motor. The mechanical output of the motor moves the command marker/counter assembly.

Now that you have traced the Command Altitude Circuit on the simplified schematic, refer to figure 2 in the vertical scale instruments handout and trace the Command Alt. Circuit. Locate the slew switch and transformer T-2 in the AVVI.

After you have traced the Command Alt. Circuit in the above handout, check the accuracy of your work with the correct answer shown in figure 32. All command signal circuits such as altitude, airspeed, and Mach are colored LIGHT GREEN.

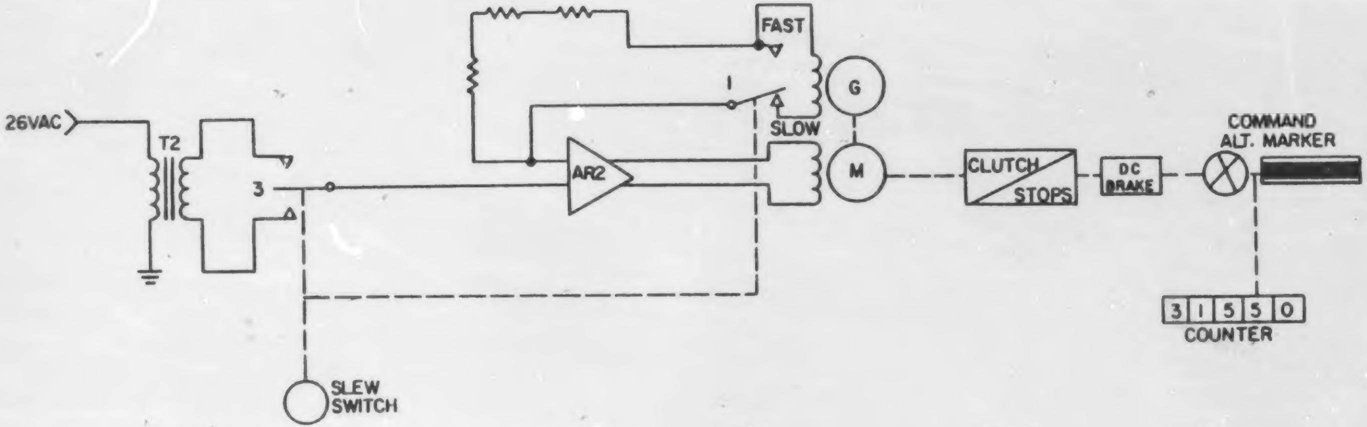

26VAC
T2
3
FAST
1
SLOW
G
M
AR2
CLUTCH
STOPS
DC BRAKE
COMMAND ALT. MARKER
3 1 5 5 0
COUNTER
SLEW SWITCH

Figure 31.

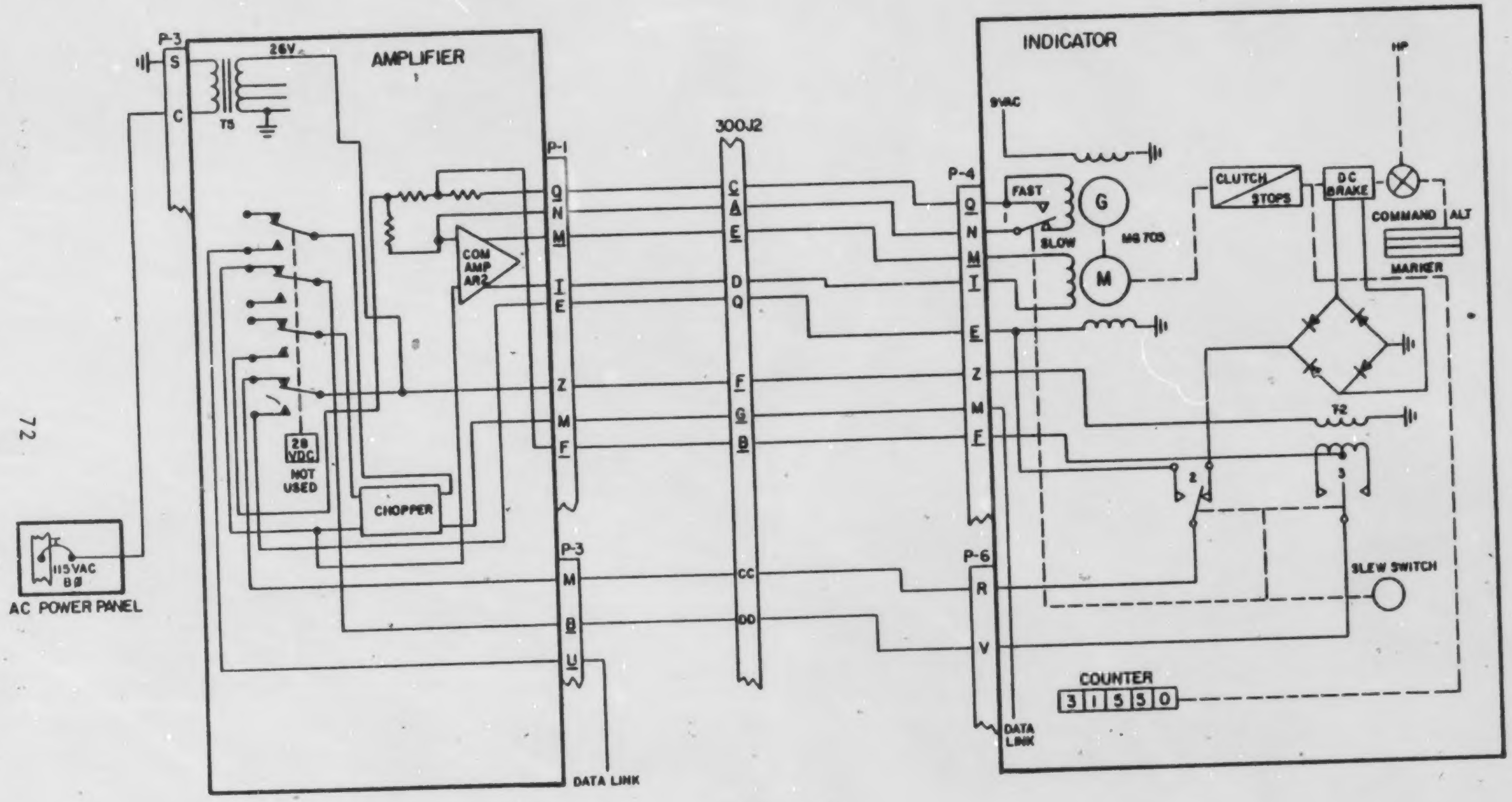

P-3
S
C
26V
T5
AMPLIFIER
28 VDC
NOT USED
CHOPPER
COM AMP AR2
P-1
O
N
M
I
E
Z
M
F
P-3
M
B
U
DATA LINK
115VAC BØ
AC POWER PANEL
300J2
C
A
E
D
Q
F
G
B
CC
DD
P-4
O
N
M
I
E
Z
M
F
P-6
R
V
DATA LINK
INDICATOR
9VAC
FAST
SLOW
G
M
MS 705
CLUTCH
STOPS
DC BRAKE
HP
COMMAND
ALT
MARKER
T-2
2
3
SLEW SWITCH
COUNTER
3 1 5 5 0

Figure 32.

You have traced most of the signals within the CADC system. Now let's check your ability to trace and analyze the CADC circuits. The Pt and Psi transducers and potentiometers establish signals and position synchros in the CADC. The synchros then move from one position to a new position according to the signal supplied. The motors drive the tapes to the position established by the synchro. The generator produces a signal opposite to that which drives the motor, stopping the tape on the exact indication without over or under travel. (Reference Frame 28 in this PT). All of this must be remembered when analyzing the abnormal indications that you soon may have to analyze and repair on the flight line.

Examples of abnormal indications are:

1. No movement (tape inoperative) - This indication could be caused by an open or short in either the fixed or variable phase of the motor circuits; an open or short in the rotor of a synchro; or a loss of power.

2. Tape erratic or unstable - This indication could be caused by an open or short in one of the stator leads of the synchro assembly.

3. Tape oscillation - This indication could be caused by an open or short in either the fixed or variable phase of the rate generator.

Use the CADC schematics provided to locate the malfunctions in the following questions. Circle the letter that identifies the correct answer.

1. During flight, the pilot reported no movement of the Mach tape.

   a. Open between pin E of P1 (J-1401) and pin V of 300J3.

   b. Short between pins K and L of P5 (J-1403).

   c. Short between pins D and J of P1 (J-1401).

   d. Open between pin L of P1 (J-1401) and pin Y of 300J3.

2. During flight, the pilot reported the movement of the calibrated airspeed tape erratic or unstable.

   a. Short between pins B and A of P5 (J-1403).

   b. Short between pins B and V of P6 (J-1301).

   c. Open between pin AA of 300J3 and pin K of P2 (J-1302).

   d. Open between pin R of 300J4 and pin C of P3 (AMI AMP).

1441

3. When the high CADC self-test is performed, the true airspeed indicator does not change indications.

a. Short between pins A and C of P1.

b. Short between pins G and H of P1.

c. Open between pin K of P1 and pin L of P4 (P-16004).

d. Open between V of 300J6 and pin C of P1.

4. During CADC self-test, the Hp tapes oscillate.

a. Open between pin P of P4 and Pin W of 300J2.

b. Open between pin K of P4 and pin Z of 300J2.

c. Short between pins K and R of P4 (J-1102).

d. Short between pins C and K of P6 (J-1101).

5. When performing CADC self-test, the movement of the Mach tape was erratic or unstable.

a. Open between pin D of P1 and pin W of 300J3.

b. Open between pin N of 300J4 and pin P of P6 (J-1301).

c. Open between pin T of P3 (P-16003) and ground.

d. Open between pin V of 300J3 and pin E of P2 (J-1302).

6. During flight, the pilot reported no movement of the vertical velocity (Hp) tape.

a. Open between pin P of P4 and pin W of 300J2.

b. Open between pin W of P4 (J-1102) and pin N of 300J2.

c. Short between pins V and U of P4 (J-1102).

d. Short between pins J and H of P5 (J-1103).

7. During the CADC self-test, the maximum safe Mach (MSM) bar did not move.

a. Open between pin R of P3 (P-16003) and pin R of P3 (J-1402).

b. Open between pin K of P7 (J-214) and pin A of P3 (J-1402).

c. Open between pin L of P5 (J-1403) and pin Q of 300J4.

d. Open between pin L of P1 (J-1401) and pin Y of 300J3.

8. During flight, the pilot reported that the angle-of-attack tape was inoperative but the indexer lites worked.

a. Short between pins AA and DD of P4 (P-16004).

b. Short between pins CC and DD of 300J4.

c. Short between pins K and Z of P1 (J-1401).

d. Short between pins B and A of 300J3.

9. During CADC self-test, the pressure altitude tapes did not move.

a. Short between pins C and D of P5 (J-1103).

b. Short between pins C and K of P6 (J-1101).

c. Open between pin P of P4 (J-1102) and pin W of 300J2.

d. Open between pin T of P3 (J-1201) and pin B of P3 (P-16003).

10. During flight, the pilot reported erratic movement of the ALPHA T tape.

a. Open between pin C of P2 (J-1302) and pin Z of 300J3.

b. Open between D of P6 (J-1301) and pin CC of 300J4.

c. Open between pin A of P1 (J-1401) and pin GG of 300J3.

d. Short between pins K and Z of P2 (J-1302).

Now that you have answered all the questions in frame 38, go back to the beginning of the PT and read all of the objectives again. Make sure that you know these objectives. If you think that you can satisfactorily answer these objectives, go to the appraisal room and take the appraisal for PT-304.

After you have completed the appraisal for PT-304, you will be given PT-304A which covers CADC System Trainer Familiarization. After the appraisal on trainer familiarization, you will be issued WB-304 which covers the operational check and troubleshooting of the CADC.

Answers to frame 40: 1. c 2. a 3. d 4. a 5. b 6. b
7. b 8. c 9. d 10. b

APPRAISAL

1443

PROGRAMMED TEXT
3ABR32531-PT-304A

Technical Training

Avionics Instrument Systems Specialist

BENCH CHECK OF THE VERTICAL SCALE FLIGHT INSTRUMENTS

1 November 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3360th Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

FOREWORD

This programmed text was prepared for use in the 3ABR32531, Avionics Instrument Systems Specialist Course. Twenty-one students enrolled in the subject course were used to validate the material herein. All students achieved the approved objective as stated. Average time to complete the PT is 1 hour and 22 minutes.

OBJECTIVE

Given a programmed text, tech data and trainer, bench check the vertical scale flight instruments with a minimum of 80% accurate workbook responses.

INSTRUCTIONS

This programmed text contains instructions for the bench check of the AMI and AVSI. Follow all instructions carefully and complete the tables as indicated. The first part of this PT is made up in normal PT format. You are required to read each frame and respond to the questions. The answers to the frames are found at the bottom of the next frame. The second part of this text instructs you in a lab procedure. You are required to make a response; your response will be verified by your instructor.

Supersedes 3ABR32531-PT-308, 17 December 1974.
OPR: TTMCW
DISTRIBUTION: X
  TTMCW - 150; TTS - 1

Frame 1

The first indicator you will bench check is the AMI. This indicator is similar to the one on the FB-111A trainer, but some of the tapes are different. The angle of attack tape is read in symbols rather than degrees. The ranges of the other tapes are also different.

Match the lettered items in figure 1 to the statements on the right.

1._____ indicates mach.

2._____ indicates airspeed in knots.

3._____ indicates max safe mach.

4._____ indicates instrument failure.

5._____ indicates aircraft "G"s.

6._____ indicates angle of attack.

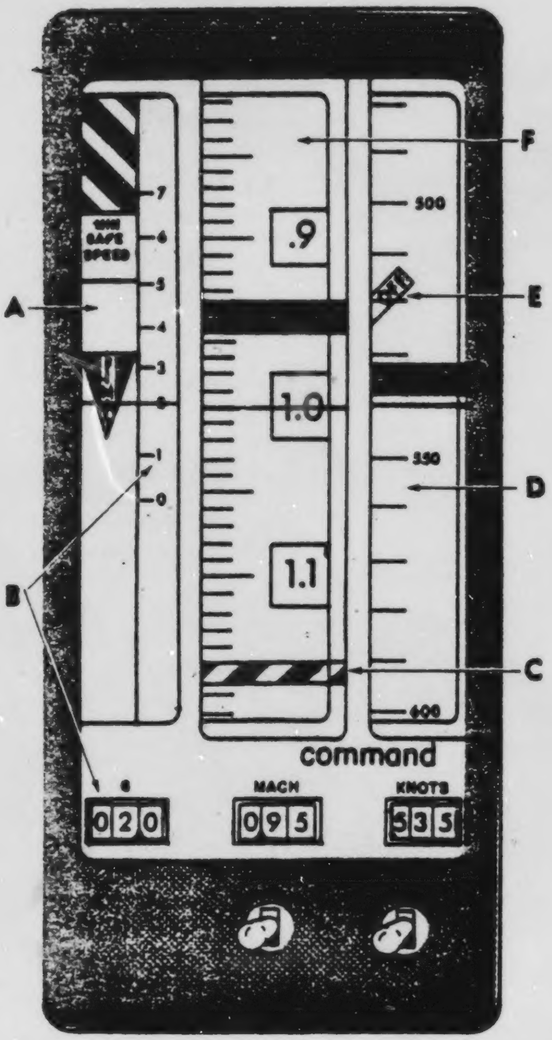

F
E
D
C
A
B
MIN SAFE SPEED
7
6
5
4
3
2
1
0
.9
1.0
1.1
500
550
600
command
G
020
MACH
095
KNOTS
535

Figure 1.

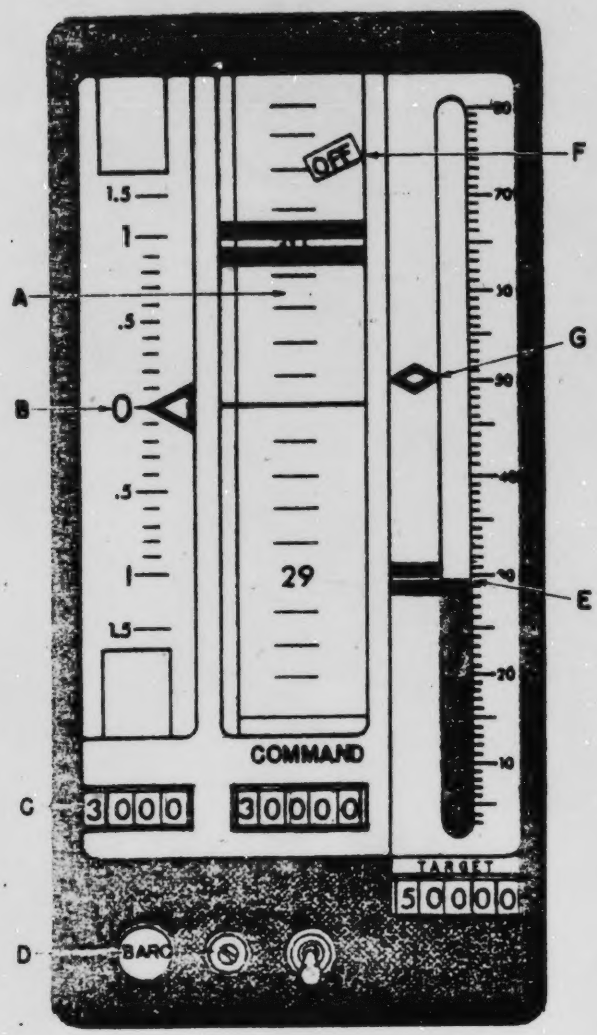
Frame 2

The second indicator you will bench check is the AVSI. This indicator is also similar to the one on the FB-111A trainer, but again, there are differences. The AVSI has only two altitude scales. They are:

1. A sensitive scale (A) which is numbered every thousand feet and marks every hundred feet as shown in figure 2.

2. A gross scale (E) with numbers every ten thousand feet and marks every thousand feet. This scale has a total range of -2,000 feet to +80,000 feet.

Match the lettered items in figure 2 to the statements on the right.



1.____ indicates rate of climb.

2.____ indicates sensitive altitude.

3.____ indicates gross altitude.

4.____ used to set barometric pressure.

5.____ indicates barometric setting.

6.____ indicates instrument failure.

7.____ indicates target altitude.

Figure 2.

Answers to Frame 1

1. F 2. D 3. C 4. E 5. B 6. A

Frame 3

Before you begin the bench check of the vertical scale flight instruments, notice that there are a lot of dials and switches on the testers. Don't become confused by them. Each control is numbered and the number is referenced in the instructions.

There are four controls that you may have some trouble reading or understanding, so we will present this information now.

First, the potentiometer #1 (figure 3) is located in the upper left corner of the tester. It consists of four (4) moveable scales. The scales are read from the outside to the inside. Each scale is referenced to a black mark on the left side of the potentiometer. All readings are decimal readings. (Example: .00000)

Using figure 3, circle the letter of the correct response to the statement below.

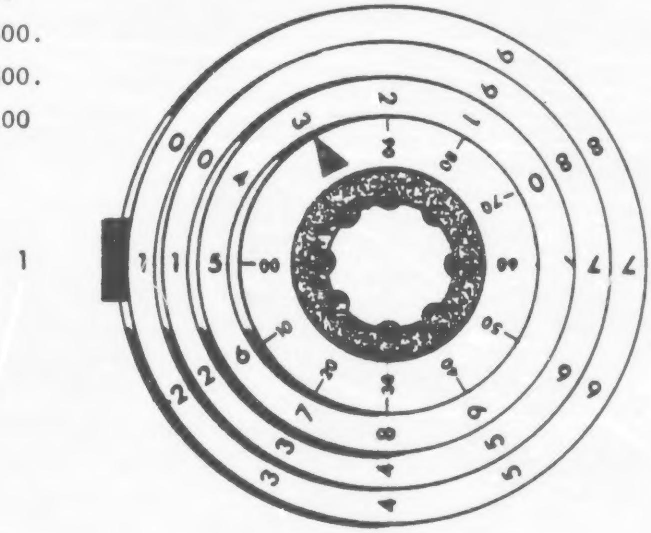
1. The reading of the potentiometer in figure 3 is

   a. .004.

   b. .11500.

   c. 1.1500.

   d. 115.00



POTENTIOMETER

Figure 3.

Answers to Frame 2

1. B 2. A 3. E 4. D 5. C 6. F 7. G

Frame 4

The Coarse and Fine synchro, controls #2 and #3, (figure 4) will be used frequently during the bench check of the vertical scale flight instruments. For this reason, it is very important that you be able to read these synchros.

Refer to figure 4. Both the Coarse and Fine synchros are read in the same manner. The inner and outer dials are read in degrees. The inner dial is in ten degree increments with every thirty degrees numbered. The outer dial is equal to a total of ten degrees with .1 degree increments.

A reading will be taken in the following manner. First of all look at the Coarse synchro. The inner dial is indicating between 160 and 170 degrees, referenced to the short pointer. In order to find the exact reading, look at the outer dial, referenced to the long pointer. The long pointer is four increments past the 5. Your reading will be 5.4 degrees. Adding the readings of the inner and outer dials you come up with a total reading of 165.4 degrees.

Take a reading of the fine synchro and record this reading in the space provided below the **fine synchro**.

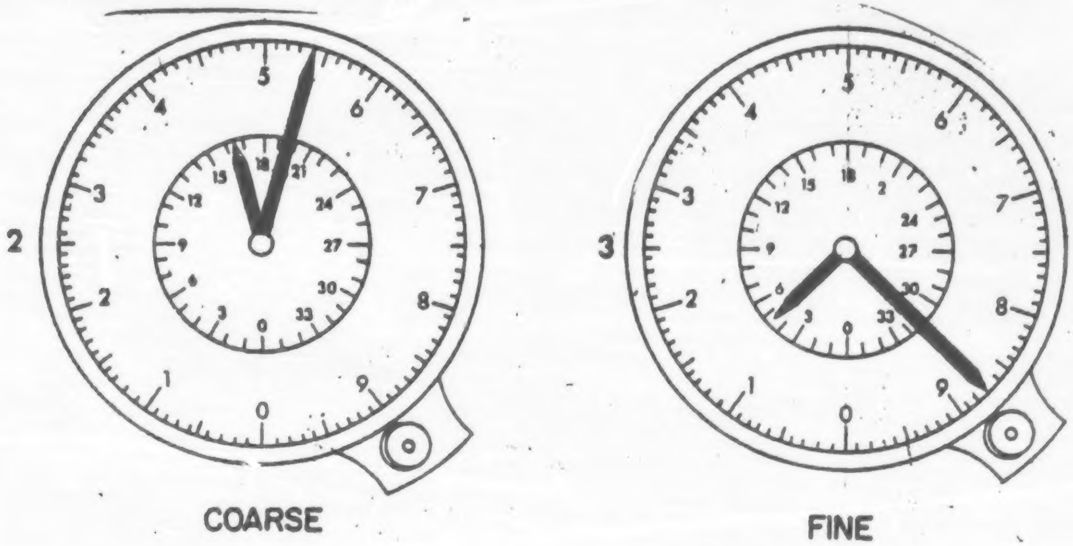


Figure 4.

FINE SYNCHRO READING

________________DEGREES

1597

Answer to Frame 3

1. [✓ b]

Frame 5

The fourth control is an AC voltmeter and a Value-Select knob. The position of the knob determines the maximum range of the AC volt scale.

For example, in figure 5, the Value-Select knob is positioned on 30, indicating that the top scale has a maximum range of 30V AC. The pointer in figure 5 is indicating 20V AC.

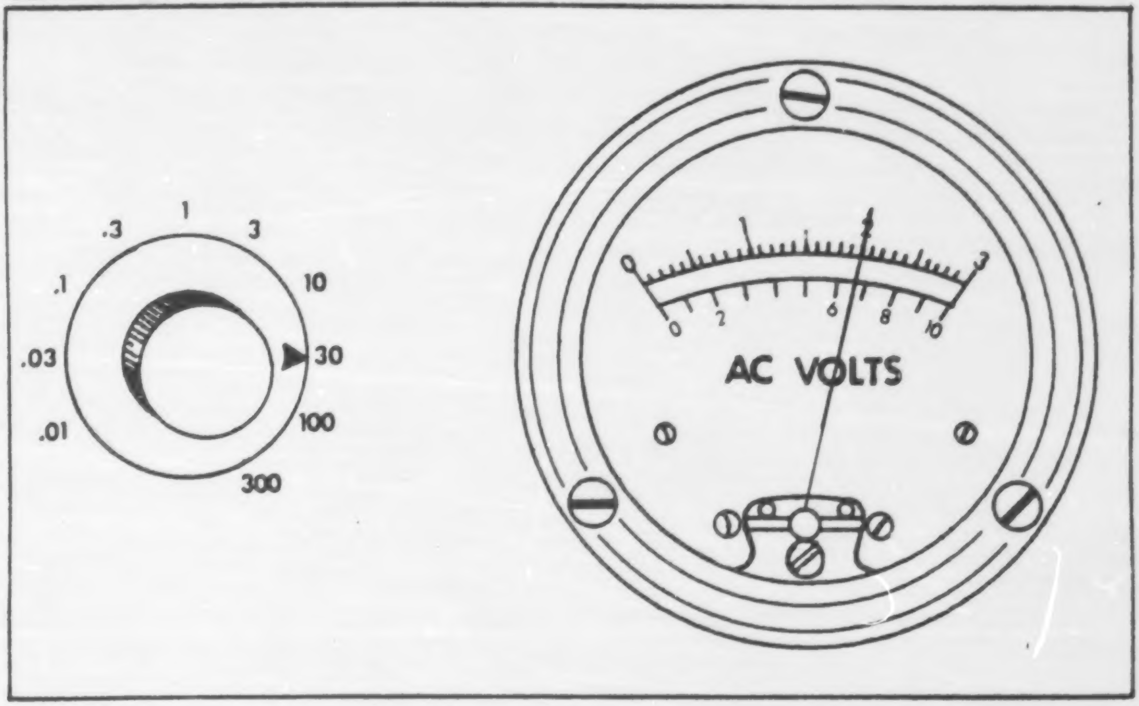

4
.3
1
3
.1
10
.03
30
.01
100
300
0
1
2
3
0
2
6
8
10
AC VOLTS

Figure 5.

1450

In figure 6, the Value-Select knob is now in a different position which changes the maximum scale value of the AC voltmeter.

Using figure 6 as a reference, record the reading of the AC voltmeter in the space provided.

4

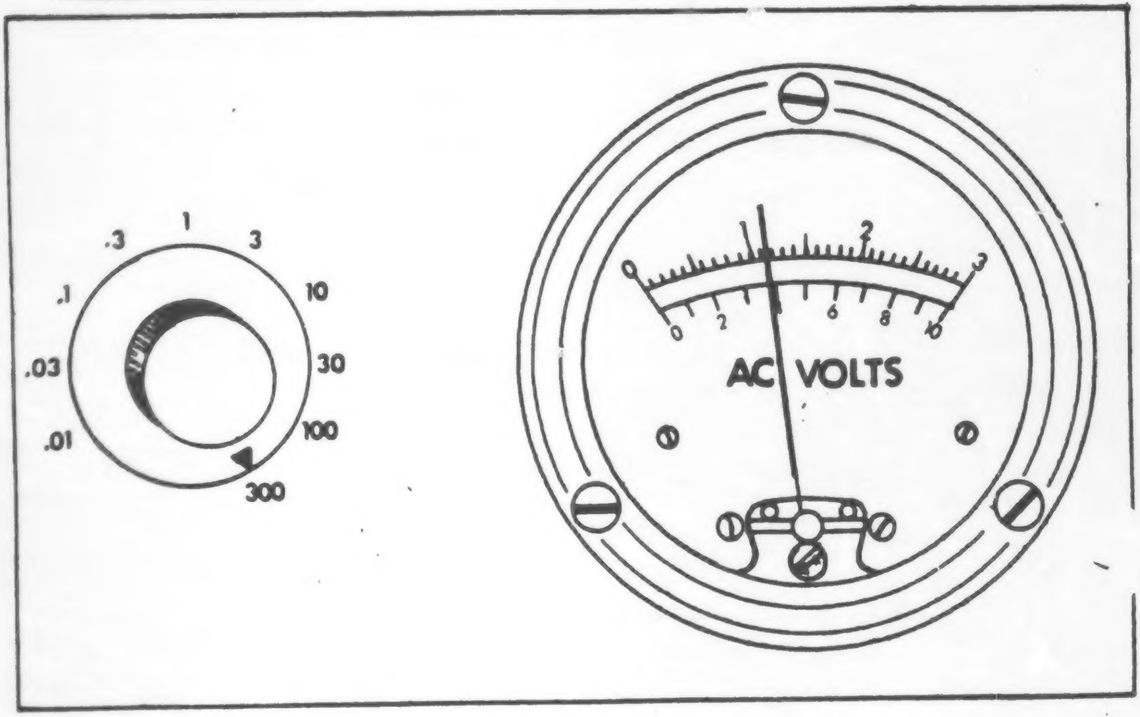

.01
.03
.1
.3
1
3
10
30
100
300
0
1
2
3
0
2
4
6
8
10
AC VOLTS

Figure 6.

Reading of AC voltmeter

_________________V AC

Answer to Frame 4

48.7 DEGREES

Answer to Frame 5

115V AC

599

BENCH CHECK

This section of the programmed text contains instructions for testing the Mach Safe Speed Airspeed Indicator. All procedures are referenced to TO 5F8-2-27-2. A special tester, the Mach number safe speed airspeed indicator test set 13A0190 or 13A0191 (referred to as test set 13A0190 or 13A0191) is used for checking the operation of the Mach safe speed airspeed indicator.

Note: Remove all jewelry!!!

Ask the lab instructor to assign you to a test set, either 13A0190 or 13A0191. Pick up TO 5F8-2-27-2, turn to page 6-1 and begin working. Check (✓) each item in your PT as you complete it.

STEP 1. Test setup--Paragraph 6-5

a. _____Perform item a.

b. _____Perform item b.

c. _____Perform item d.

d. _____Perform item e.

STEP 2. Preliminary tests--Paragraph 6-6

a. _____Perform item a.

b. _____Perform item b.

c. _____Perform item c.

d. _____Perform item d.

_____Satisfactory _____Unsatisfactory (check one)

e. _____Perform item e.

_____Satisfactory _____Unsatisfactory (check one)

STEP 3. Scale error tests--Paragraph 6-7

a. Aircraft Mach-Paragraph 6-8

(1) _____Perform item a.

(2) _____Perform item b.

Note: Flag for P/N 18000-1B-4-D1 and 18000-1B-4-E1 Indicators will disappear only in the I.A.S. Mode.

(3) _____Perform item c and complete table 1.

1452

Note: Perform step 3, item c (in your PT), the Maximum Safe Mach test (paragraph 6-10) and complete table 3 at this time. (See Note: Paragraph 6-10)

COARSE 2 (Degrees)	FINE 3 (Degrees)	MACH READING	ERROR TOLERANCE (MACH)	ACTUAL READING	RESULTS (S or U)

Table 1. Aircraft Mach Test

b. Indicated Airspeed--Paragraph 6-9

(1) _____Perform item a.

(2) _____Perform item b and complete table 2.

COARSE 2 (Degrees)	FINE 3 (Degrees)	INDICATED AIRSPEED READING	ERROR TOLERANCE (Knots)	ACTUAL READING	RESULT (S or U)

Table 2. Indicated Airspeed Test.

c. Maximum Safe Mach--Paragraph 6-10
After recording the indicator mach readings for each of the mach settings in table 1, perform the following steps.

(1) _____Rotate the FINE 3 transmitter to the FINE 3 setting in table 3 which corresponds with the desired mach reading in table 1.

1511

(2) _____Set PROGRAM SEL 7 switch to Max Safe Mach and record Maximum Safe Mach Readings in table 3.

(3) _____Return PROGRAM SEL 7 switch to Mach after each reading and rotate COARSE 2 and FINE 3 settings in table 1 for the next Aircraft Mach check.

Note: COARSE 2 settings in table 3 are taken from table 1. Since initial aircraft Mach test settings in table 1 have no corresponding Maximum Safe Mach setting in table 3, proceed to the second pair of aircraft Mach test settings in table 1 before performing the Maximum Safe Mach test procedure.

COARSE 2 (Degrees) (Table 1)	FINE 3 (Degrees)	MAXIMUM SAFE MACH READING	ERROR TOLERANCE (MACH)	ACTUAL READING (MACH)	RESULTS (S or U)
0	0				
60	60				
90	90				

Table 3. Maximum Safe Mach Test.

d. G Limiting--Paragraph 6-11

(1) _____Perform item a.

(2) _____Perform item b and complete table 4.

FINE 3 (Degrees)	G LIMIT READING	ERROR TOLERANCE (G)	ACTUAL READING (G)	RESULTS (S or U)

Table 4. G Limiting Test.

e. Minimum Safe Speed--Paragraph 6-12

(1) _____Perform item a.

(2) _____Perform item b and complete table 5.

FINE 3 (Degrees)	SAFE SPEED READING	ERROR TOLERANCE (Degrees)	RESULTS (S or U)

Table 5. Safe Speed Test.

f. Command Mach--Paragraph 6-13

(1) _____Perform item a.

(2) _____Perform item b.

(3) _____Perform item c.

(4) _____Perform item d.

_____Satisfactory _____Unsatisfactory (check one)

(5) _____Perform item e.

(6) _____Perform item f and complete table 6.

POTENTIOMETER SETTING	COMMAND MACH	ERROR TOLERANCE (Mach)	ACTUAL READING (Mach)	RESULT (S or U)

Table 6. Command Mach Test, Automatic Mode.

g. Command Indicate Airspeed--Paragraph 6-14

(1) _____Perform item a.

(2) _____Perform item b.

(3) _____Perform item c.

_____Satisfactory _____Unsatisfactory (check one)

(4) _____Perform item d.

(5) _____Perform item e and complete table 7.

POTENTIOMETER SETTING	COMMAND AIRSPEED READING	ERROR TOLERANCE (Knots)	ACTUAL READING (Knots)	RESULT (S or U)

Table 7. Command Indicated Airspeed Test, Automatic Mode.

STEP 4. Test Set Shut-Down Procedure

a. At this time you have completed the bench check of the Mach Safe Speed Airspeed Indicator.

b. _____Place circuit breakers #24 and #25 to "OFF" position.

c. _____Disconnect the tester power from the 115 VAC power source.

Note: Have the lab instructor check your work and then proceed to bench check the altitude vertical speed indicator.

____
Instructor's Signature

This section of the programmed text contains the test procedure for bench checking the Altitude Vertical Speed Indicator. A special test set the altitude vertical speed indicator test set 13A0180 or 13A0181 is used for checking the operation of the altitude vertical speed indicator. All procedures are referenced to TO 5F8-9-10-2.

Note: Remove all jewelry!!!

Ask the lab instructor to assign you to a test set either 13A0180 or 13A0181. Pick up TO 5F8-9-10-2, turn to page 6-1 and begin working. Check (✓) each item in your PT as you complete it.

STEP 1. Test Setup--Paragraph 6-5

a. _____Perform item a.

b. _____Perform item b.

c. _____Perform item d.

STEP 2. Preliminary Tests--Paragraph 6-6

a. _____Perform item a.

b. _____Perform item b.

c. _____Perform item c.

d. _____Perform item d.

STEP 3. Scale error tests

Note: For all scale error tests BARO setting should read 29.92" Hg.

a. Sensitive altitude operation checks--Paragraph 6-7

(1) _____Perform item a.

(2) _____Perform item b and complete table 8.

COARSE 2 (Degrees)	FINE 3 (Degrees)	ALTITUDE READING (Feet)	ACTUAL READING (Feet)	RESULTS (S or U)

Table 8. Sensitive Altitude Checks.

1457

b. Command Altitude Operational Checks--Paragraph 6-9

(1) Automatic Mode--Paragraph 6-10

(a) _____Perform item a.

(b) _____Perform item b and complete table 9.

POTENTIOMETER SETTING	COMMAND ALTITUDE READING (Feet)	ACTUAL READING (Feet)	RESULTS (S or U)

Table 9. Command Altitude Operational Checks Automatic Mode.

(2) Manual Mode--Paragraph 6-11

(a) _____Perform item a.

(b) _____Perform item b.

_____Satisfactory _____Unsatisfactory (check one)

c. Vertical Speed Section Tests--Paragraph 6-12

(1) _____Perform item a.

(2) _____Perform item b and complete table 10.

(3) _____Perform item c and complete table 11.

1458

POTENTIOMETER SETTING	CLIMB VERTICAL SPEED READING (ft/min)	ERROR TOLERANCE (ft/min)	ACTUAL READING (ft/min)	RESULT (S or U)

Table 10. Climb Vertical Speed Test.

POTENTIOMETER SETTING	DIVE VERTICAL SPEED READING (ft/min)	ERROR TOLERANCE (ft/min)	ACTUAL READING (ft/min)	RESULT (S or U)

Table 11. Dive Vertical Speed Test

d. Target Altitude Operational Check--Paragraph 6-14

(1) _____Perform item a.

(2) _____Perform item b and complete table 12.

1517

POTENTIOMETER SETTING	TARGET ALTITUDE MARKER READING (Feet)	ACTUAL READING (Feet)	RESULTS (S or U)

Table 12. Target Altitude Operational Check.

STEP 4. Test Stand Shut-Down Procedure

a. At this time you have completed the bench check of the Altitude Vertical Speed Indicator.

b. _____Place circuit breakers #28 and #29 to the "OFF" position.

c. _____Disconnect the power cable from the 115 VAC power source.

Note: Have the lab instructor check your work.

____
Instructor's Signature

1460

PROGRAMMED TEXT
3ABR32531-PT-304B
3ABR32632B-PT-404B

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

CADC SYSTEM TRAINER FAMILIARIZATION

8 November 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3360th Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

1519

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

FOREWORD

This programmed text has been prepared for use in the 3ABR32531 and 3ABR32632B, Avionics Instrument Systems Specialist and Integrated Avionic Systems Specialist courses. The material herein has been validated by 32 students enrolled in the courses. At least 90% of the students achieved the stated objective with an average time of 53 minutes to complete the text.

OBJECTIVE

Without references, identify facts pertaining to the operation and/or characteristics of air data computer systems to a minimum accuracy of 80%.

INSTRUCTIONS

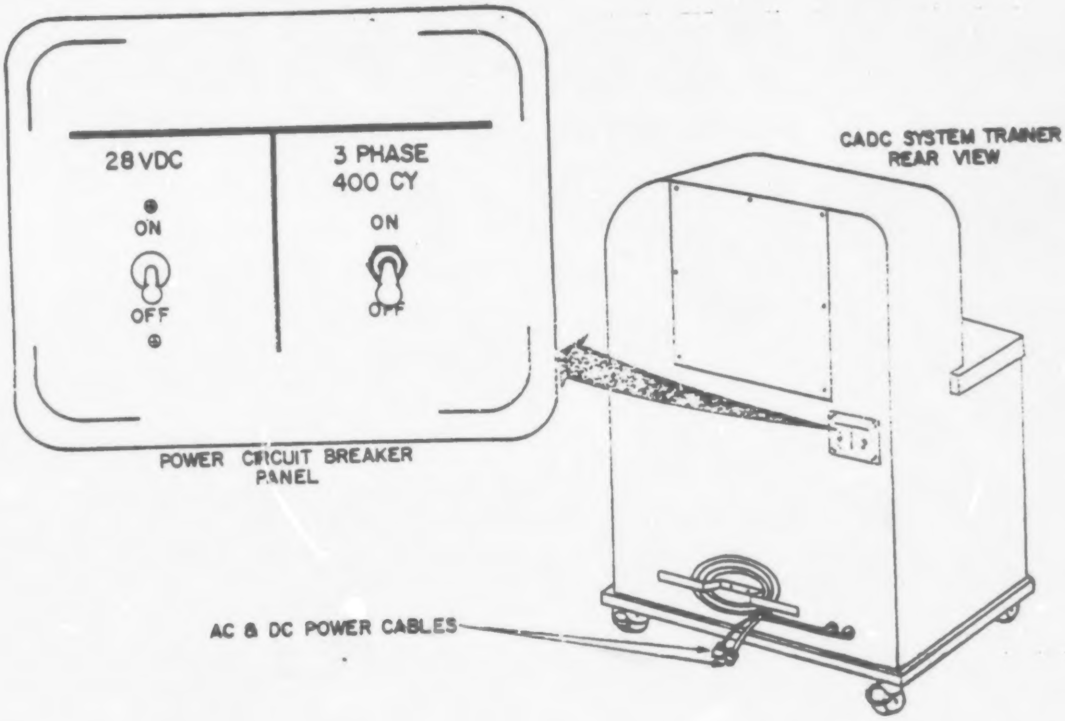
This programmed text presents information in small steps called "frames." After reading the information in each frame, you are asked to select an answer or make an entry that shows that you understand the information in that frame. DO NOT WRITE IN THIS BOOKLET. As you are reading each frame, cover the area below the slanted lines. You may check the accuracy of your answers by uncovering the area below the slanted lines.

Supersedes 3ABR32531-PT-306, 3ABR32632B-PT-402B, 23 January 1976, which may be used until existing stocks are exhausted.
OPR: 3360 TTG
DISTRIBUTION: X
TTMCW - 200; TTS - 1

To be able to troubleshoot malfunctions inserted into the trainer an understanding of the trainer and the differences between the trainer, aircraft and the CADC system must be learned. Both the trainer and the aircraft have the CADC system installed on their framework. There are many more components on an aircraft than are needed on the trainer. On the trainer we have to simulate some of these components and the signals from these components. As in the aircraft a power source is required to operate the trainer and the CADC system. The CADC system power is obtained from the trainer power section. To connect the trainer to its power requirements, connect the power cables to the power source. The trainer is protected by its own circuit breakers as illustrated below.

Caution: Serious injury to personnel and damage to equipment can result from incorrect procedures in applying power to the CADC trainer.

The power circuit breaker panel shown below provides trainer protection for 28VDC and 115/208V 3-phase, 400-Hertz AC. This panel and location are shown below.



Mark T for True or F for False in the space provided for each statement below.

_____ 1. The power circuit breaker panel is located on the front of the CADC system trainer.

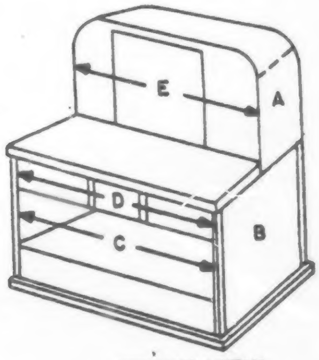
_____ 2. The circuit breaker panel provides trainer protection for 28VDC and 115/208V 3-phase, 400-Hertz AC.

_____ 3. The circuit breakers must be in the "OFF" position before connecting the AC and DC power cables.

_____ 4. The AC and DC power cables are located in the rear of the CADC system trainer.

1464

CADC system components are mounted on the trainer framework. The framework has been divided into sections as illustrated. (Sections A, B, C, D, and E.)



FRONT VIEW

Section A contains the α probe, total temperature probe, inlets for pitot and static pressures and a power receptacle for connecting test equipment to the system. Section A also contains test points for use in troubleshooting wiring from the α probe and T_1 probe.

Section B contains test points simulating the escape capsule (more frequently termed escape panel) disconnect connectors. These test points are located on the right side of the trainer as shown.

Section C simulates the electronic equipment bay of the aircraft and contains the CADC unit, MSMA amp, AMI amp, AVVI amp, and test points for each of these components.

Section D contains 3 control panels. One is used for trainer power, and two are used to simulate inputs to the CADC system. Test points for each of these components are located in Section D.

Section E contains the system circuit breakers on the left, a simulated cockpit instrument panel in the center section, and the trainer malfunction panel (under a door labeled TRAINER MALFUNCTION PANEL) on the right side. This whole section is referred to as the instrument panel.

Note: All test points on the trainer allow you to troubleshoot and locate instructor induced malfunctions without disconnecting CADC system components connector plugs.

NO REPONSE REQUIRED

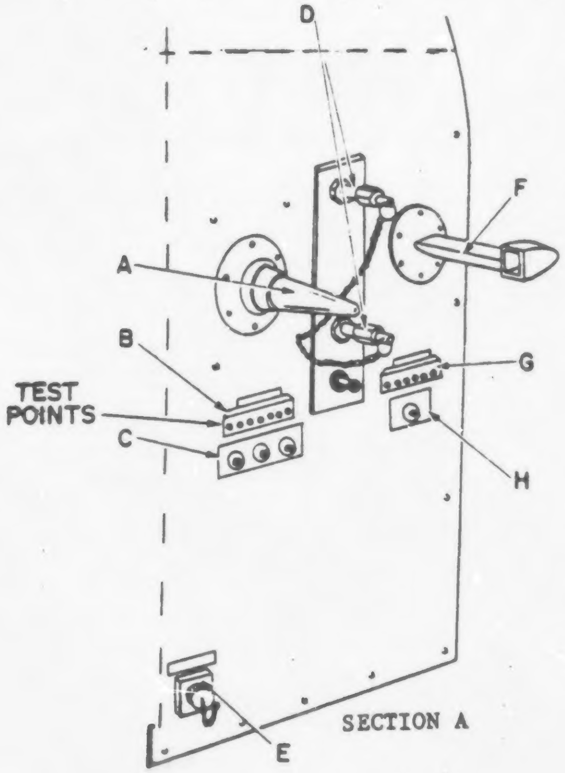
/////////////////////////////////

Answers to Frame 1: F 1. T 2. T 3. T 4.

1523

Frame 3

Section A of the CADC system is located on the right hand side of the trainer. This section contains some very important equipment. The angle of attack probe, commonly called the alpha probe, is located in this section.



SECTION A

The alpha probe (A) is shown in the panel at the left. By manually rotating the α probe, the indexer lights and angle of attack indicator will operate. Directly under the α probe you will find the probe test points (B). Three RED lights (C) under the α probe are used to indicate α probe heater operation.

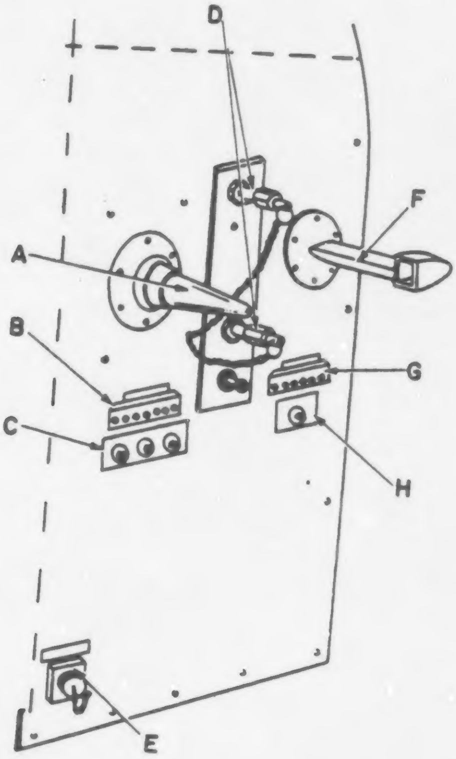
Pitot and static connectors (D) are located on this part of the trainer. The pitot and static connectors are different sizes which prevents incorrect hookups of a pressure test set. These two connectors are the only pressure inputs to the trainer. Therefore, the tester being used to perform a trainer leak test, will be connected at these points. The Ps and Pt hoses will be connected to the pressure inputs on the trainer.

An AC power connection (E) is used to supply power to the TTU-205C/E pressure test set, which is used for leak checks on the trainer.

The total temperature probe (F) is located beside the pitot-static connectors. The test points (G), located under the T_i probe, are used for troubleshooting. A single RED light (H) located under the T_i probe test points, is used for T_i probe heater operational checks.

Match the name of the component with the letter in the panel below.

1. _____ T_i probe test points.
2. _____ α probe.
3. _____ AC power connector.
4. _____ T_i probe heater light.
5. _____ Pitot-static connectors.
6. _____ α probe heater lights.
7. _____ α probe test points.

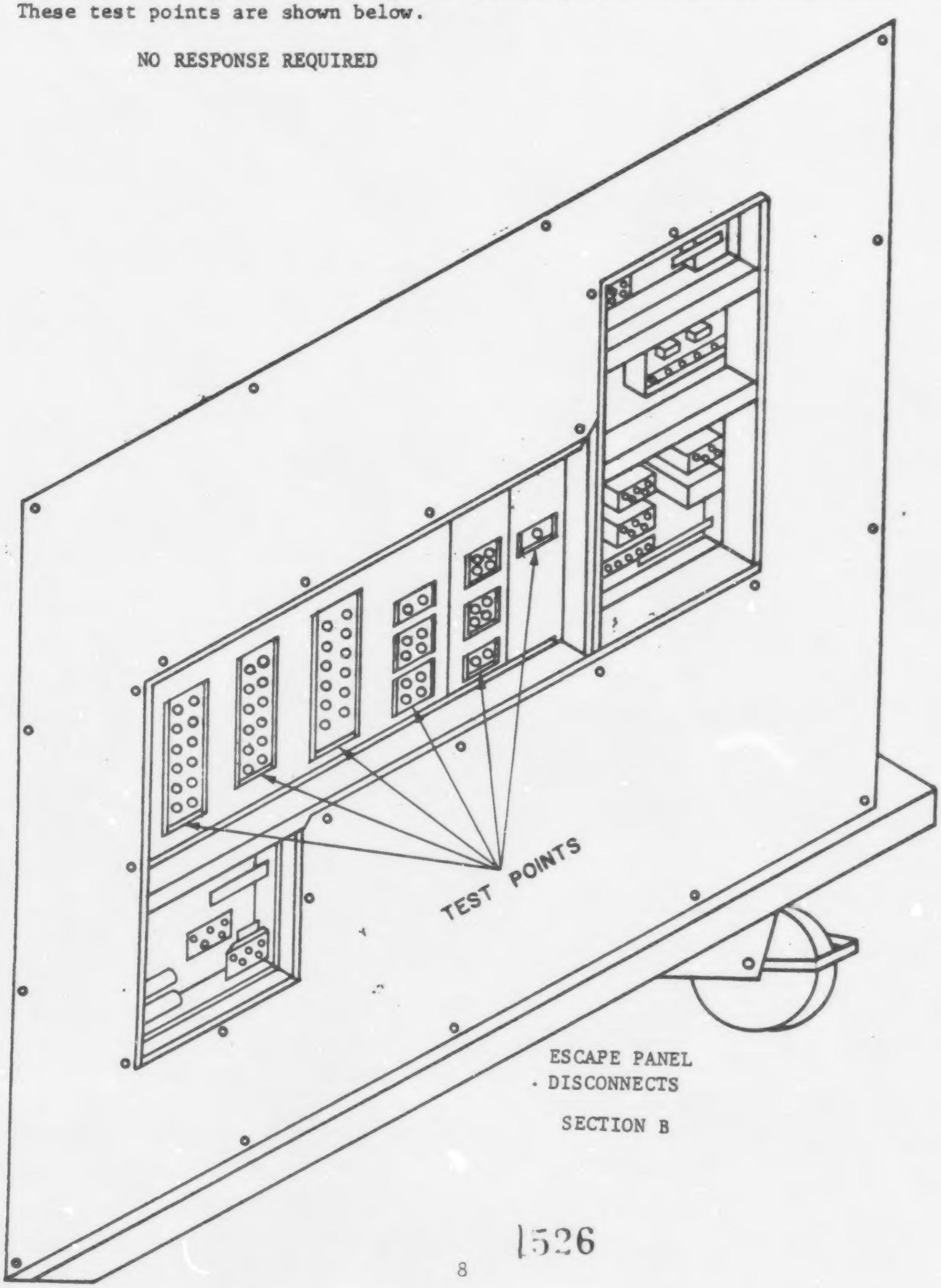


1467

Frame 4

Section B located on lower right side of the trainer contains test points simulating the escape capsule (escape panel) disconnect connectors. These test points are shown below.

NO RESPONSE REQUIRED



ESCAPE PANEL
DISCONNECTS

SECTION B

Frame 5

Section C, located on the lower front of trainer, simulates the electronic equipment bay and contains the CADC unit, MSMA amp, AMI amp, AVVI amp, and test points for each located under the component.

All of these components (plus some built in self-testing devices) are shown below. The name of each component is lettered and listed below.

A. AVVI amplifier.

B. AMI amplifier.

C. MSMA self-test light.

D. MSMA press to test switch.

E. CADC self-test light.

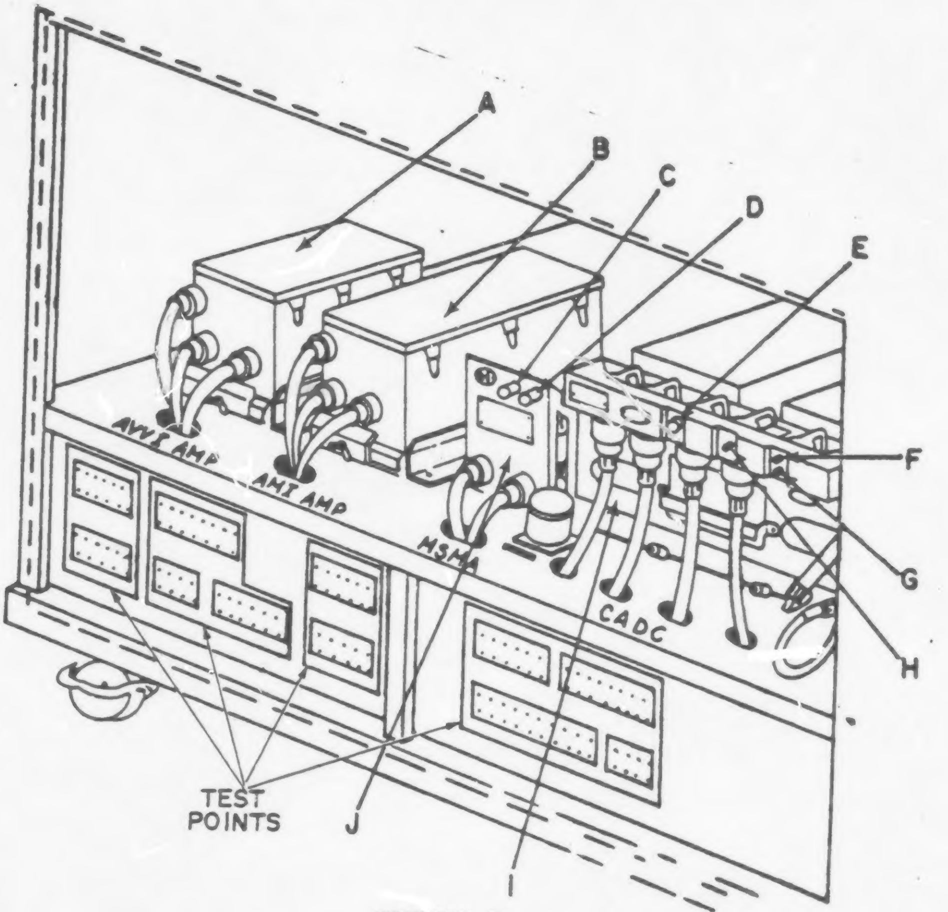
F. CADC HI self-test switch.

G. CADC LO self-test switch.

H. CADC press to test switch.

I. CADC unit.

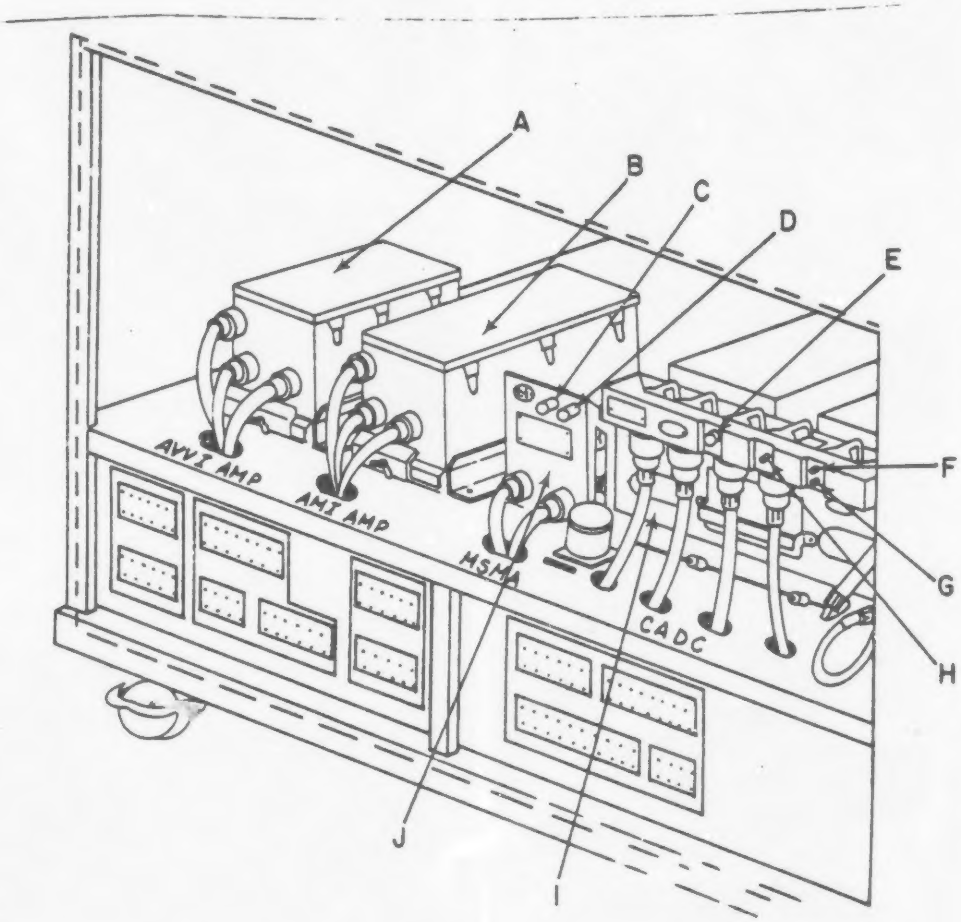
J. MSMA amplifier.



SECTION C

1469

Match the name of the components to panel shown below by placing the letters in the spaces provided.



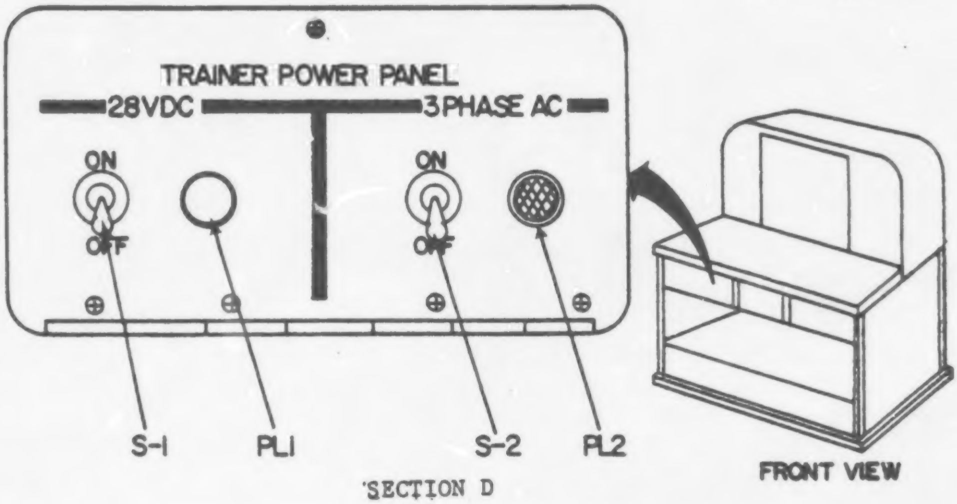
1. _____ CADC unit.
2. _____ MSMA amplifier.
3. _____ CADC self-test light.
4. _____ AVVI amplifier.
5. _____ MSMA press to test switch.
6. _____ CADC HI self-test switch.
7. _____ CADC press to test switch.
8. _____ AMI amplifier.
9. _____ MSMA self-test light.
10. _____ CADC LO self-test switch.

////////////////////////////////

Answers to Frame 3: 1. G 2. A 3. E 4. H 5. D 6. C 7. B

1528

The trainer power panel is located on Section D of the trainer. This panel is shown on the diagram below. The CADC system trainer power panel is located on the lefthand side of Section D. There are two switches and two lights located on this panel. The two switches are the DC and AC power switches. S-1 supplies DC power to the trainer and S-2 supplies AC power to the trainer.



SECTION D

Mark T for True and F for False in the space provided for the statements below.

_____ 1. Trainer power panel is located on the front of the CADC system trainer.

_____ 2. S-1 supplies AC and DC power to the CADC system.

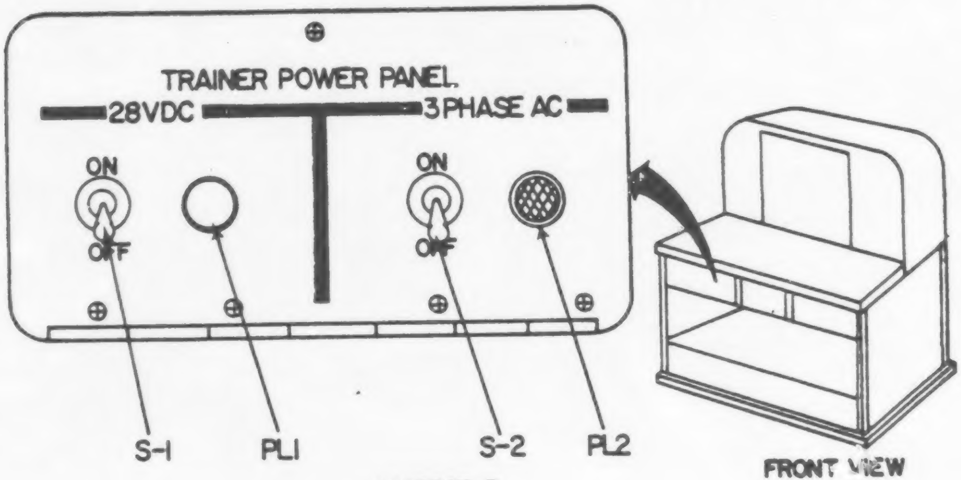
_____ 3. S-2 supplies AC power to the trainer.

////////////////////////////////

Answers to Frame 5: 1. I 2. J 3. E 4. A 5. D 6. F 7. H 8. B 9. C 10. G

Frame 7

The two lights located on the CADC system power panel are the PL1 light and PL2 light. The PL1 light is the 28VDC indicator light and the PL2 light is the AC indicator light. When the PL2 light is illuminated it shows that 115/208V 3-phase 400 Hz AC power in the correct phasing is applied to the trainer. This indicator light must be illuminated before the DC and AC control switches are placed to the "ON" position. The trainer power panel is the second step in applying power to the CADC system.



SECTION D

Mark T for True or F for False in the space provided for the statements below.

_____ 1. PL2 indicates DC power applied to the trainer.

_____ 2. PL1 indicates DC power applied to the trainer.

_____ 3. PL2 indicates AC power applied to the trainer.

///////////////////////////////

Answers to Frame 6: 1. T 2. F 3. T

Frame 8

Now that you know how to apply power to the CADC trainer, there are a couple of trainer peculiarities that you should know. (Trainer peculiarity refers to equipment on the trainer not to be found on the aircraft). A trainer simulator panel located on the front of the trainer (Section D) is one of these peculiarities. It is used to simulate inputs to the CADC system that would normally be supplied by components that are not a part of the CADC system. The trainer simulator panel shown below contins the following controls:

1. Wing Sweep Position Control - Provides simulation of wing sweep.

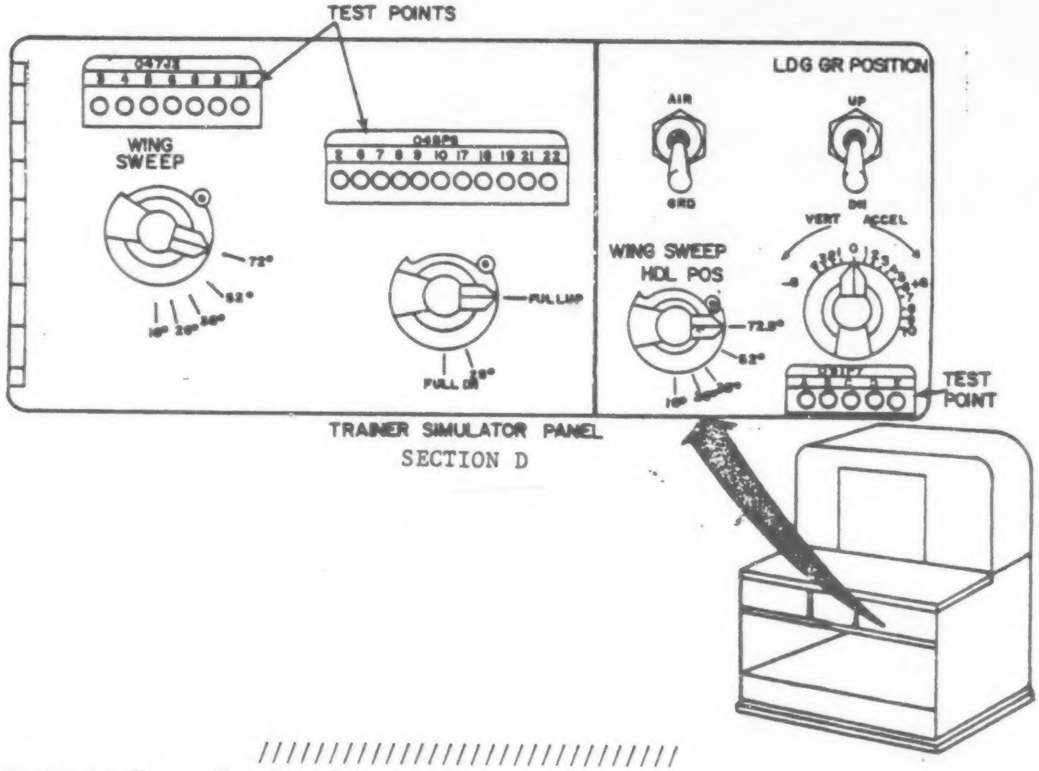
2. Wing Flap Position Control - Provides simulation of wing flap and slat movement.

3. Landing Gear Position Switch - Simulates gear up or gear down.

4. Wing Sweep Handle Control - Provides simulation of wing sweep handle.

5. Vertical Acceleration Control - Provides simulation of "G" forces.

The panel also contains test points of Wing Sweep, Wing Flap, and Vertical Acceleration for troubleshooting purposes.


TEST POINTS
WING SWEEP
72°
52°
16°
20°
30°
FULL UP
FULL DN
20°
LDG GR POSITION
AIR
GRD
UP
DN
VERT ACCEL
WING SWEEP HDL POS
72.5°
52°
TEST POINT

TRAINER SIMULATOR PANEL
SECTION D

//////////////////////////////

Answers to Frame 7: 1. F 2. T 3. T

1473

Match the list of controls with their functions by placing the number of the control in the spaces provided for each function.

1. Vertical Acceleration Control
2. Wing Sweep Handle Control
3. Landing Gear Position Switch
4. Wing Sweep Control
5. Wing Flap Control

_____ a. Provides simulation of wing sweep.

_____ b. Provides simulation of wing flap and slat movement.

_____ c. Landing gear (Up - Down) simulation.

_____ d. Provides simulation of "G" forces.

_____ e. Provides simulation of wing sweep handle.

1532

Frame 9

Many times the actual aircraft equipment cannot be used. Therefore the equipment is simulated. Simulated means representing aircraft equipment. It is not necessarily a true representation of the actual thing. Section "E" contains the simulated cockpit instrument panel. Located on this panel are the CADC system circuit breaker panel, the simulated instrument panel, the CADC ground check panel, and the trainer malfunction panel. The instrument panel is outlined in the center of Section "E". Reference Frame 2, Page 3, Section "E".

The Section "E" panel shown on the next page shows all of the components and panels identified for your reference. Below is a list of these components referenced to that panel.

A. Total temperature indicator.

B. Reduce speed light.

C. Indexer lights.

D. AMI indicator.

E. AVVI indicator.

F. Standby airspeed indicator.

G. Standby vertical velocity indicator.

H. True airspeed indicator.

I. Standby altimeter.

J. α/b (Alpha probe heater malfunction light).

K. T_1 malfunction light.

L. Ground check panel (contains the CADC system power switch).

M. CADS (Warning light for the CADC system).

N. External environment control panel.

O. Flight control test panel.

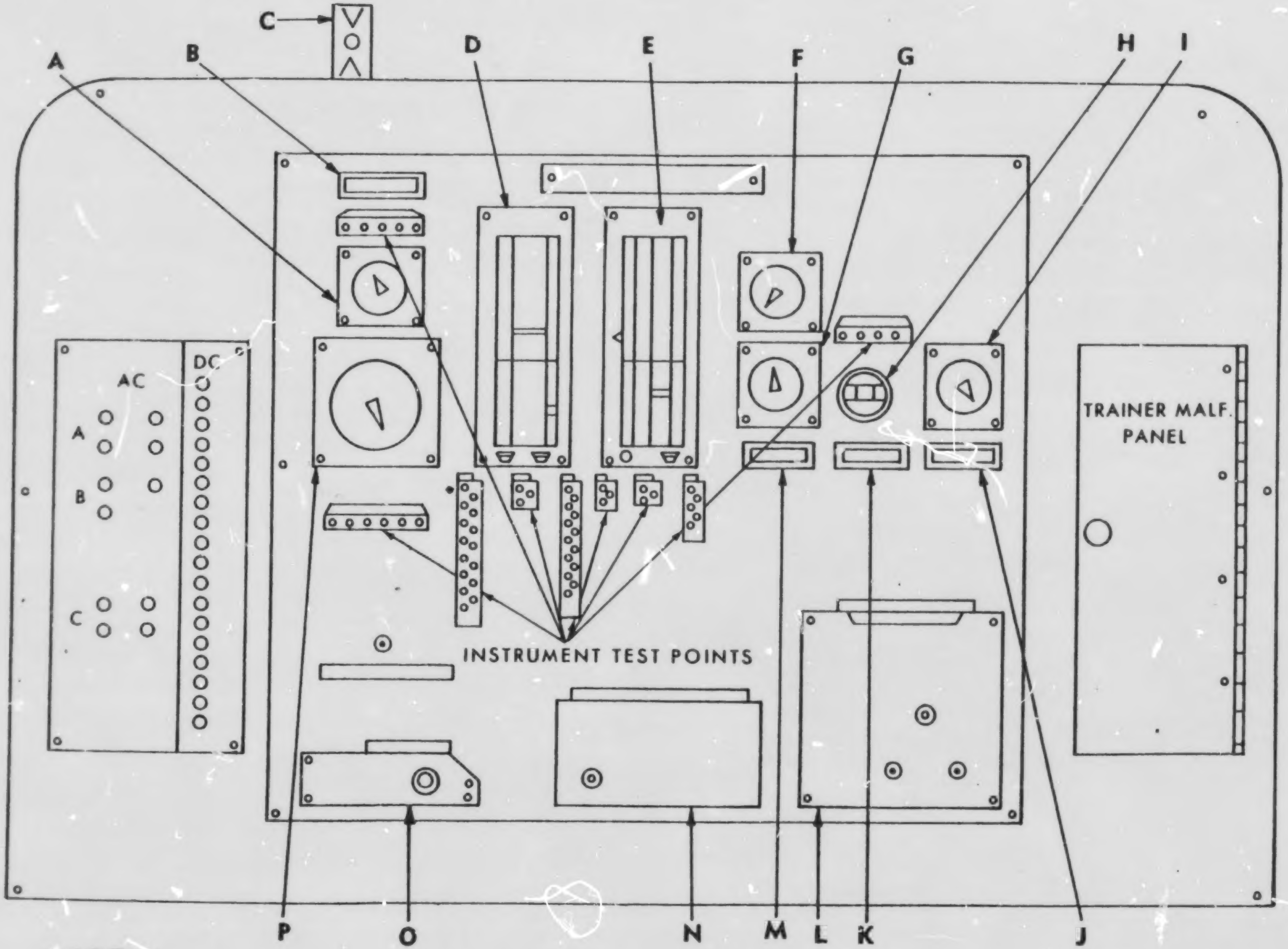
P. Wing sweep indicator.

////////////////////////////////

Answers to Frame 8: a. 4 b. 5 c. 3 d. 1 e. 2

Match the names of the components and panels to the panel shown on Page 14 by placing the letters in the spaces provided.

1. _____ AMI indicator.
2. _____ Standby airspeed ind.
3. _____ Standby altimeter.
4. _____ T_i malfunction light.
5. _____ External environment control panel.
6. _____ T_i indicator.
7. _____ Indexer lights.
8. _____ AVVI indicator.
9. _____ Reduce speed light.
10. _____ CADC warning light.
11. _____ Wing sweep indicator.
12. _____ Standby vertical velocity ind.
13. _____ True airspeed indicator.
14. _____ α/b (probe heater light).
15. _____ Ground check panel. (CADC system power switch.)
16. _____ Flight control test panel.


C
A
B
D
E
F
G
H
I
AC
DC
A
B
C
TRAINER MALF. PANEL
INSTRUMENT TEST POINTS
P
O
N
M
L
K
J

1535

SECTION E

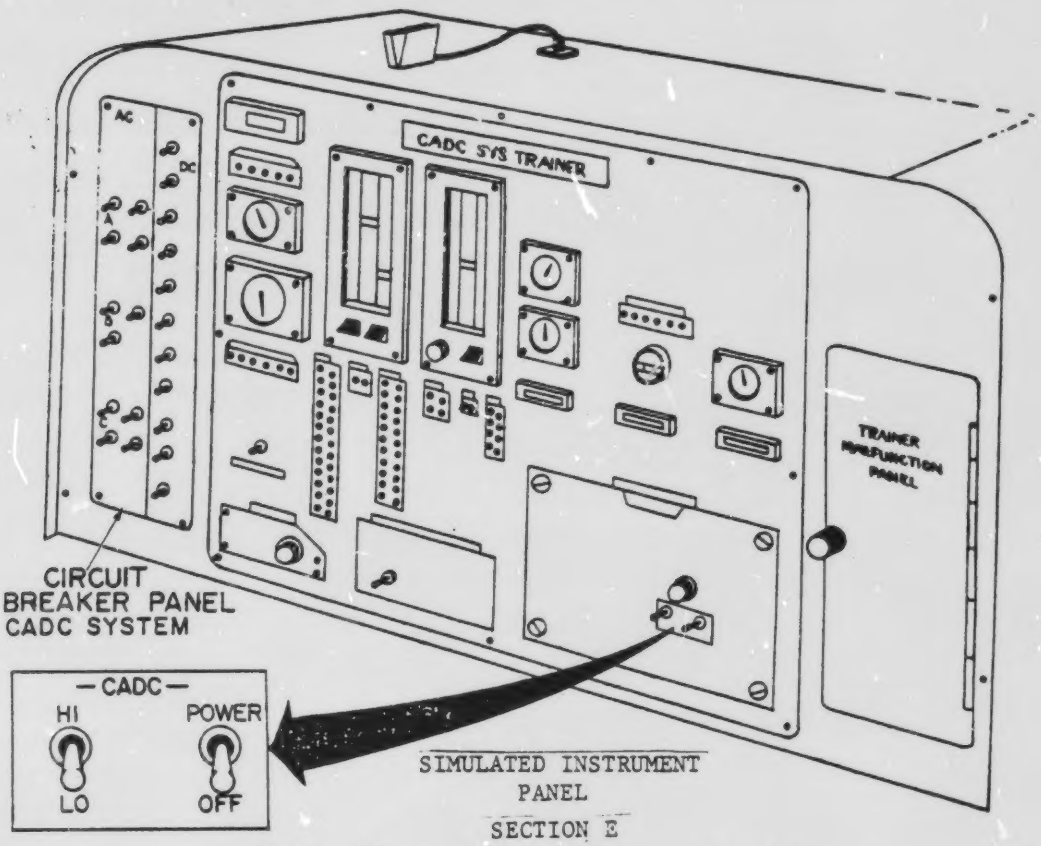
1536

1476:

Frame 10

The ground check panel of the simulated instrument panel contains the CADC system power switch. This ground check panel was mentioned in "L" of the previous frame. The CADC system power switch must not be confused with the trainer power switch contained in Section "D". The CADC system power switch supplies power to operate the CADC system which is located in the trainer.

NO RESPONSE REQUIRED


AC
DC
A
B
C
CADC SYS TRAINER
TRAINER MALFUNCTION PANEL
CIRCUIT BREAKER PANEL CADC SYSTEM
— CADC —
HI
LO
POWER
OFF
SIMULATED INSTRUMENT PANEL
SECTION E

////////////////////////////////

Answers to Frame 9: 1. D 2. F 3. I 4. K 5. N 6. A
7. C 8. E 9. B 10. M 11. P 12. G 13. H 14. J
15. L 16. O

WORKBOOK
3ABR32531-WB-304
3ABR32632B-WB-404

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

CENTRAL AIR DATA SYSTEM
(INSPECT, OPERATIONAL CHECK, AND TROUBLESHOOT)

1 February 1977

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

Instrument Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-304
3ABR32632B-WB-404

CENTRAL AIR DATA COMPUTER SYSTEM

OBJECTIVES

Given a workbook, test equipment and trainer, perform an inspection and operational check of an air data computer system with a minimum of 100% accurate workbook responses.

Given a workbook, test equipment and trainer, troubleshoot an air data computer system with a minimum of 75% accurate workbook responses.

EQUIPMENT

	Basis of Issue
Central Air Data Computer Trainer	2/student
Schematic Diagrams 3ABR32632B-HO-404/3ABR32531-HO-304	2/student
Multimeter, AN/PSM-6	2/student
AFTO Forms 349	As required

PROCEDURE

This workbook is divided into three sections; A, B, and C. After completing each section, check with your instructor so he can certify your answers are correct. Read all steps carefully. REMOVE ALL JEWELRY.

Section A

VISUAL INSPECTION

Have your instructor assign you a trainer and then complete a visual inspection of it. Place a checkmark (√) in the correct column.

1. Check for:	Satisfactory	Unsatisfactory
a. Missing components	______	______
b. Damaged or disconnected cannon plugs	______	______
c. Loose or frayed wiring	______	______
d. Damaged components	______	______

2. Notify the instructor if any discrepancies are found.

Supersedes ST 3ABR32632B-WB-404, 3ABR32531-WB-304, 30 April 1976; 3ABR32531-WB-306, 26 March 1975; 3ABR32632B-WB-502, 15 May 1974, which may be used until existing stocks are exhausted.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC-W - 200; TTVSR - 1

3. Prepare the CADC trainer for pre-operational checks.

a. Insure that the CADC power switch is in the OFF position. The CADC power switch is located on the ground check panel.

b. Insure that the AC and DC power switches located on the left front of the trainer below the table top are in the OFF position.

c. Insure that the AC and DC power switches located on the rear of the trainer are in the OFF position.

4. Complete the following pre-operational checks on the trainer control panels.

CONTROL	LOCATION	POSITION
Malfunction switches	Right side of instrument panel	Out
System circuit breakers	Left side of instrument panel	In
Pitot/Probe heat	External environmental control panel	OFF/SEC
CADC high-off-low switch	Ground check panel	OFF
Barometric set	AVVI	29.92" Hg
CADC-MSMA simulated temperature panel	Center front-below table top	NORM
Wing sweep position control	Right front-below table top	16°
Wing sweep handle position control	Right front-below table top	16°
Flap position control	Right front-below table top	Full up
Landing gear safety switch	Right front-below table top	GRD
Landing gear position switch	Right front-below table top	DN
Vertical acceleration (G) control	Right front-below table top	+1G

After all controls have been checked and set IAW section A, have the instructor verify completion of section A before proceeding to section B.

Instructor's Initials ____________________

Section B

OPERATIONAL CHECK OF THE CENTRAL AIR DATA SYSTEM

1. Insure that all controls are in the positions outlined in section A of this workbook.

2. Insure that all circuit breakers are engaged.

Note: Power to the trainer is furnished through facility drop cords. Each drop cord is properly marked either 115V AC, 400 Hz, or 28V DC.

3. Connect the two (2) power cables on the back of the trainer to their proper facility drop cord.

4. Place AC and DC power switches on the back of the trainer to the ON position

5. Place the AC and DC power switches, located on the left front of the trainer below the table top, to the ON position.

Note: The AC and DC power lamps will light. If they fail to light, return AC and DC power switches to the OFF position and notify the instructor.

6. Position the CADC power switch, located on the ground check panel, to the "POWER" position.

7. Allow the vertical scale indications to stabilize.

8. Observe that the signal reliability flags on the airspeed tape and the course altitude tape go out of view and that the CADS lamp goes off.

9. Operate the three (3) slewing switches (2 on the AMI and 1 on the AVVI). Observe that you have two speeds up and two speeds down. Insure that there is movement of the mach, airspeed and altitude digital counters, and command markers.

10. Rotate the vertical accelerometer control and insure that there is movement of the accelerometer tape and the accelerometer counter.

11. Rotate the angle of attack transmitter located on the right side of the trainer. Observe movement of the angle of attack tape and angle of attack indexer.

12. Depress and hold the press-to-test button and the low test button on the front panel of the CADC. The CADC lamp shall light and go out immediately.

13. Release the press-to-test and low test buttons. Allow the CADC to stabilize.

14. Depress and hold the press-to-test button and the CADC high test button. The CADC lamp shall light and then go out within 60 seconds.

15. Release the press-to-test and CADC high test buttons. Allow the CADC to stabilize.

16. Place the airspeed slewing switch to the DETENT position.

17. Depress and hold the master test button and position the CADC high-off-low switch to the low position and hold. Indications shall drive to the values listed below.

a. Altitude (Hp) 2,000' + or - 220'

b. Mach (M) .40 M

c. Airspeed (Vc) 153 knots + or - 19 knots

Note: The airspeed tape and counter must agree. + or - 3 knots.

d. Vertical velocity (Hpr) - Slight climb then return to 0 fpm + or - 100 fpm.

e. Angle of attack (α t) 7° + or - .75°

Note: The lower "V" shall be lit on the angle of attack indexer.

f. True airspeed (Vt) 157.6 knots + or - 13 knots.

Note: The signal reliability flags on the airspeed tape and altitude tape shall be in view and the CADS lamp shall be lit.

18. Release the master test button and the CADC high-off-low switch and allow the CADC to stabilize.

19. Depress and hold the master test button and position the CADC high-off-low test switch to the high position and hold. Indications shall drive to the following listed values.

Note: The maximum safe mach bar shall come into view and rise upscale between .57 and .97 mach indications.

a. Altitude (Hp) 60,000' + or - 220'

b. Mach (M) 2.3 M + or - .05 M

c. Airspeed (Vc) * See note below. - 493 knots + or - 19 knots.

d. Vertical velocity (Hpr) - 40,000 fpm climb when altitude reaches 60,000' Hpr shall read 0 fpm + or - 100 fpm.

1483
75°

e. Angle of attack (α t) ** See note below - 10° + or -

f. True airspeed (Vt) - 1348.8 knots + or - 13 knots.

Note: * The airspeed tape and counter must agree. + or - 3 knots.

** The "center circle" shall be lit on the angle of attack indexer.

The signal reliability flags on the airspeed tape and altitude tape shall be in view. The CADS lamp and the REDUCE SPEED lamp shall be lit.

20. Release the master test button and the CADC high-off-low switch, and allow the CADC to stabilize.

21. Depress and hold the instrument test button located on the ground check panel. The following indications shall be observed.

a. Altitude (Hp) - 74,000' + or - 150'

b. Airspeed (Vc) - 800 knots + or - 10 knots.

c. Mach (M) - 2.44 M + or - .01 M.

22. Release the instrument test button and allow the tapes to stabilize.

23. Depress and hold the press-to-test button and the high test button on the front panel of the CADC. Allow the CADC lamp on the front panel of the CADC to light and then go off. CONTINUE TO HOLD THE TEST BUTTONS.

24. Depress and hold the maximum safe mach self-test button located on the maximum safe mach assembly.

25. The maximum safe mach assembly self-test lamp shall light and then go off within 20 seconds, at which time the REDUCE SPEED lamp shall be lit and the maximum safe mach bar shall indicate 2.20 mach.

26. Release all test buttons and allow the CADC and the MSMA to stabilize.

27. Place the CADC power switch to the OFF position. Observe that one (1) OFF flag on the AMI and one (1) OFF flag on the AVVI are in view. Also observe that the CADS lamp has illuminated.

28. Place the AC and DC power switches on the front of the trainer to the OFF position.

29. Place the AC and DC power switches on the rear of the trainer to the OFF position and disconnect the trainer power cables. Proceed to section C of this workbook.

Section C

TROUBLESHOOTING THE CENTRAL AIR DATA COMPUTER SYSTEM

1. Set the trainer controls IAW section A, steps 3 and 4 of this workbook.

2. Complete the first 7 steps IAW section B of this workbook.

3. Place the malfunction switch (designated by the instructor) to the IN position and verify each malfunction by performing the operational check IAW section B of this workbook.

Note: The actual malfunctions may not be as described in the workbook problems, or may not exist at all.

4. Write the actual malfunction in the "Discrepancy" block on the AFTO Forms 349.

5. Obtain an AN/PSM-6 from your instructor.

6. Using the multimeter and vertical scale flight instruments wiring diagrams, identify the cause of the malfunction and record the cause on the AFTO Form 349.

7. Using the 1F-111(B)A-06 Work Unit Code Manual, complete the AFTO Form 349 blocks listed below.

1 - Job Control No.
2 - Workcenter
3 - I.D. No./Serial No.
7 - Priority
A - Type Maintenance
C - Work Unit Code
D - Action Taken
E - When Discovered
F - How Malfunctioned

8. Repeat steps 1 through 7 of this section until all assigned malfunctions have been completed.

9. Give all completed material to your instructor.

Instructor's Initials ____________________

TROUBLESHOOTING PROBLEMS

1. Capt. Williams reported that during his flight in aircraft 63-0063 the AOA read -10°. Job number 320-0001 was assigned to your shop A92AB, on a priority 2.

2. Your shop, A92AB, received job number 345-0002 as a priority 2 requirement. The write up noted that Colonel Jones had AOA problems during his flight in aircraft 68-0299.

3. Job number 022-0003 assigned to your shop A92AB, priority 2. Lt. Winston wrote up the "G's" tape as reading off scale during his flight in aircraft 64-0142.

4. "G" tape inoperative was the discrepancy noted by Major Walker during his mission in aircraft number 67-0314. Maintenance control assigned job number 004-0004 to your shop A92AB, priority 2.

5. General Thompson wrote up the cross-hatched bar on the AMI as being at the top of the scale during his flight. Job number 022-0005 was assigned to your shop A92AB, against aircraft number 065-0013 under a priority 2.

6. Job number 055-0006 was assigned to your shop A92AB, on a priority 2. Major Huston noted that the MSM bar was in view at all times during his flight on aircraft 67-014.

7. 029-007 was job number that maintenance control assigned to your shop A92AB. The pilot of aircraft 62-0084, Captain Mason, noted that during his pre-flight inspection the command mach could not be set; this was a priority 2.

8. Your shop, A92AB, received a priority 2 job from maintenance control, with an assigned number of 037-0008. The problem was written up by Major Royce as "erratic mach tape" and was discovered during a functional check flight on aircraft 67-0222.

9. Lt. Scott noted that the mach tape appeared jerky during his flight in aircraft 69-0009. Job control number 047-0009 was assigned to your shop A92AB, with a priority 2.

10. Lt. Scott also discovered that the AMI slew switch was inoperative. Maintenance control assigned job number 047-0010 to your shop A92AB, to cover the in-flight discrepancy on aircraft 69-0069 on priority 3.

11. Airspeed indicator erratic was the problem that Colonel Barnhardt discovered during his flight in aircraft 66-0245. Job number 283-0011 was assigned to your shop A92AB, as a priority 2.

12. The pilot of aircraft 65-0222 discovered that the AMI OFF flag was in view. Major Taylor stated that this condition existed during the entire flight. Your shop A92AB, was given job number 184-0012 priority 2.

13. The discrepancy was discovered in flight by Colonel Garner and written up as "erratic altitude tape." The aircraft number was 65-0185. Your shop A92AB, received from maintenance control, job number 333-0013 with a priority 2.

14. Captain Craig, during his flight in aircraft 66-0477, noticed a fluctuating altitude tape. Maintenance control gave your shop A92AB, job number 287-0014, priority 2.

15. Maintenance control gave your shop A92AB, job number 299-0015 to cover Lt. King's in-flight write up on an inoperative altitude slew switch on aircraft 69-0711, priority 3.

16. During his mission in aircraft 70-0143, Captain Kidd reported an inoperative VVI. Your shop A92AB, was given job number 157-0016 by maintenance control priority 2.

17. Major Disaster's mission in aircraft 62-0123 resulted in an abort when he discovered a CADS warning lamp ON during his pre-flight checks. Job number 231-0017 was assigned to your shop, A92AB, by maintenance control priority 2.

18. The TAS indicator erratic was the problem discovered by Colonel Hall during his flight in aircraft 66-0062. Your shop A92AB, was assigned job number 011-0018 on a priority 2.

19. A burned out doughnut light on the AOA indexer was the discrepancy noted by Captain Marvel during his flight in aircraft 67-0193. 001-0019 was the job number sent to your shop, A92AB by maintenance control with a priority 2.

20. Colonel Canyon had an AVVI OFF flag come into view about half way through his flight in aircraft 69-0072. Due to the nature of the problem, the Colonel then aborted the mission. Maintenance control gave job number 007-0020 to your shop, A92AB on a priority 2.

WORKBOOK
3ABR32531-WB-~~307~~ 305A

Technical Training

Avionics Instrument Systems Specialist

BENCH CHECK OF THE AIR DATA COMPUTER

17 November 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3360th Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-307

BENCH CHECK OF THE AIR DATA COMPUTER

OBJECTIVE

Given a workbook and test equipment, bench check components of an air data computer system with a minimum of 80% accurate workbook responses.

EQUIPMENT

	Basis of Issue
AN/ASM-201B, Test Bench	1/2 students
TTU-205C/E Pneumatic Test or Pressure and Pitot-static Control Panel	1/2 students

PROCEDURE

Remove all jewelry. Read this workbook carefully, it will guide you through the bench check.

SPECIAL NOTE

Do not let the many dials and switches confuse you. If you experience problems in attaining the specified indications, back up and reaccomplish the steps for that particular test. Most likely you have misadjusted a dial or left a step out all together. Do this as often as necessary to learn the process. If you still can not solve the problem, consult the instructor.

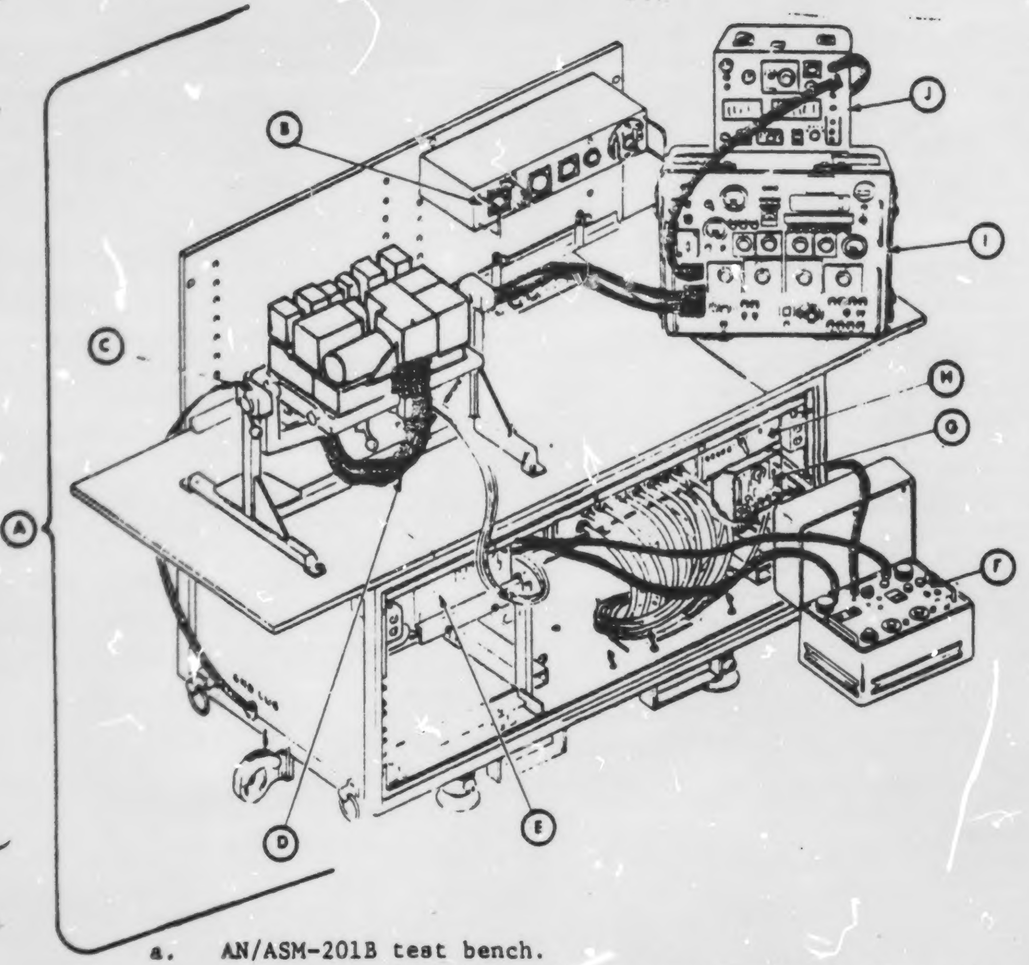
All the equipment has been hooked up properly, except for the electrical connectors and possibly the pitot static pressure lines of the TTU-205C/E. The pitot pressure and pitot-static pressure panel may be used in place of the TTU-205/E if necessary. Keep this in mind when you make adjustments throughout this lab project.

Many of the steps listed in this workbook were taken from the applicable technical order. However, some of the steps have been rearranged and simplified to enhance student learning. Keep in mind that you must always use the current technical order when performing maintenance of instrument systems in the field.

Before you begin the bench check of the air data computer, you should become familiar with the abbreviations found in this workbook. Below are the abbreviations and their meanings for your reference.

ADC	AIR DATA COMPUTER
ADCTS	AIR DATA COMPUTER TEST SET
AEUTS	ALTITUDE ENCODER UNIT TEST SET
SMPT	SPC MODULE PNEUMATIC TESTER
PTTS	PRESSURE TEMPERATURE TEST SET (TTU-205C/E)
TAS	TRUE AIRSPEED

This supersedes 3ABR32531-WB-307, 14 March 1975.
OPR: 3360TTG
DISTRIBUTION: X
3360TTGTC-W - 200; TTVSR - 1



a. AN/ASM-201B test bench.
b. Instrument display assembly - contains angle of attack indicator, airspeed mach indicator, vertical velocity indicator and the TAS indicator.
c. Computer holder.
d. Special purpose cable to computer.
e. Pneumatic regulator--CN-826/ASM82 (AC power switch, mode switch and vacuum pump).
f. TTU-205C/E pressure temperature test set or pitot pressure and pitot-static control panel as a substitute.
g. Pneumatic tester/SPC module.
h. Pneumatic manifold-HD-532/ASM82 (engine bleed air (Pr) control).
i. Computer test - AS-270.
j. Altitude encoder test set - ASM-270A.

STEP 1

Locate the ADC model number listed on the nomenclature plate of the particular ADC under test. List this number here __________.

Read the following paragraphs and follow the directions as indicated further in this workbook. Refer to this page for component identification.

AIR DATA COMPUTER TESTING

ADC testing is divided into two categories; (1) operational testing and (2) functional testing. The operational test is a complete test of the operational readiness of the ADC. This test is performed on newly received ADC's and as quality assurance after maintenance on the ADC. The functional tests are tests of specific ADC functions. These tests are performed to verify reported malfunctions, analyze malfunctions and assure quality after corrective action has been taken.

ADC OPERATIONAL TEST

PRELIMINARY CONTROL SETTINGS

Set up each test set as the table requires.

CONTROL	SETTING
(ADCTS)	
POWER	OFF
TEMP°R	492
ANGLE OF ATTACK	0
BIT	OFF
CLUTCH	OFF
COMMAND/RATIO	RATIO
TAS/SPC COMMAND AC-DC RATIO	5000
AMPLIFIER	OFF
RATIOMETER INPUT	OFF
VTVM INPUT	EXT
VOLTMETER INPUT	AC AØ
MODULE CALIBRATE	INT
42400 MODEL	SEE NOTE BELOW
MODULE	SPC
AMPLIFIER VOLTAGE	OUTPUT
NOTE: WHEN TESTING MODEL NUMBER 42400-227, SET 42400 MODEL DIAL TO 215. FOR MODEL 42400-229, SET DIAL TO 205.	
(AEUTS)	
POWER	OFF
ALIGNMENT	OFF
TRVM RANGE	300
RESPONSE	FAILSAFE
TEST MODE	CADC
VOLTMETER INPUT	DC-5
ENCODER	READOUT
TRVM INPUT	EXT
FAILSAFE	RESET
FAIL MODE	DC
Ln Ps-41 SPEED	FULL CCW
Ln Ps-41 MODE	ADJUST
Ln Ps-41 REFERENCE ALTITUDE	00,000
AEU OUTPUT MODE	ADJUST
AEU OUTPUT SYNCHRO	B3

CONTROL	SETTING
(SMPT)	
BAROMETRIC CORRECTION KNOB	—
POWER	ON
STATIC PRESS SWITCH	INDICATED
(INSTRUMENT DISPLAY PANEL)	
MODE	TEST
(PNEUMATIC REGULATOR)	
AC POWER	OFF
VACUUM PUMP	OFF
MODE SELECTOR	COMPTR. COMPEN.
(PNEUMATIC MANIFOLD)	OFF
CONTROL	
(TTU-205C/E)	
MACH LIMIT	2.8
FREQUENCY	OFF
ALT. RATE X 1,000 FEET/MIN	5
A/S, RATE KNOTS	250
TEMPERATURE SIMULATOR	30.00
AMPLITUDE, ALTITUDE/AIRSPEED	0
ALTITUDE FEET	740
AIRSPEED KNOTS	50
TRIM CONTROLS	CENTER OF TRAVEL
Ps AND Pt VENT VALVES (2)	CLOSED
LEAK TEST SWITCHES (2)	OFF
ALTITUDE HOLD	NORMAL
POWER	OFF

STEP 2

1. Connect power cables; 115V AC 400 Hz, 115V AC 60 Hz, 28V DC to their respective power outlets.

2. Turn all six (6) power circuit breakers, located on top of the bench to the ON position. Multiple switches count as one.

3. Open RED pressure valve behind the test bench CCW.

STEP 3

PRELIMINARY PROCEDURES

Follow procedures column for proper dial and switch settings, observe and compare normal indication column with actual indications. Check S or U for satisfactory or unsatisfactory completion of this area.

	PROCEDURE	INDICATION
1	SET ADCTS POWER SWITCH TO ON	A0, B0, C0 AND 28V DC LIGHTS GO ON FAILSAFE AND CORR OFF LIGHTS GO ON
2	SET ADCTS VOLTMETER INPUT TO: EXT DC 74 EXT DC 28 INT DC 74 INT DC 28 INT DC 10 AC C0 AC B0 AC 26 AC A0	VOLTMETER READINGS: 65 TO 80 25.5 TO 30.5 70 TO 78 25.5 TO 30.5 9 TO 11 108 TO 122 108 TO 122 24 TO 28 108 TO 122
3	SET AEUTS POWER TO ON AND ALLOW ALTITUDE TO STABILIZE	POWER LIGHT GOES ON, DISREGARD FAILSAFE AND SYNC LIGHTS IF ON
4	SET AEUTS VOLTMETER INPUT TO: DC -5 DC 5 DC 28 AC 10 AC 26 AC 115	VOLTMETER READINGS: 4.25 TO 5.75 4.25 TO 5.75 27 TO 29 9 TO 11 24 TO 28 109 TO 121
5	SET PNEUMATIC REGULATOR AC POWER TO ON	AC POWER LIGHT GOES ON _____S or _____U

STEP 4

Read and understand the ABNORMAL PRESSURE CONDITIONS procedures below.

ABNORMAL PRESSURE CONDITIONS

In the event that the altitude and/or airspeed range of the test set is exceeded when the power switch is turned on, the appropriate warning lamp will illuminate, the green lights will extinguish and the pump will stop. To correct the abnormal pressure conditions accomplish the following:

1. Move the switch from NORMAL to READ EXT mode. Blower will stop running, and all power is removed from the test set except the ALTITUDE and AIRSPEED indicators.

2. Slowly open the pitot VENT valve until the airspeed indicator shows that pitot pressure is near ambient pressure.

3. Slowly open the static VENT valve until the altitude indicator shows that altitude is near ambient pressure.

Note: The pitot pressure line should be vented to atmosphere before venting the static pressure line. This prevents creating a negative differential pressure. In any event, check valves in test set that are connected between the pitot and static output lines prevents more than 1/2" Hg negative differential pressure from being developed. This protection is present whether the test set power is ON or OFF or whether the test set is in NORMAL or READ EXTERNAL modes of operation.

4. Close the static and pitot vent valves and restore operation by adjusting the airspeed and altitude controls to ambient settings, and place the test switch from READ EXT to NORMAL.

The MACH LIMIT LAMP (RED) will illuminate whenever an airspeed is commanded that exceeds the limit value corresponding to the existing altitude and the setting of the LIMIT SET control. The airspeed counter will run up only to the limit value, not up to the command value. The mach limit conditions may be corrected by:

1. Reducing the commanded airspeed.

2. Reducing the actual altitude.

3. Increasing the setting of the MACH LIMIT control.

Note: If a mach number greater than 3.00 is desired, place the mach limit switch in the DISABLED position.

STEP 5

TEST SET STARTUP PROCEDURES

	PROCEDURE	INDICATION
1	SET TTU-205/E POWER SWITCH TO ON	TEST SET NORMAL LAMP WILL LIGHT FAN WILL OPERATE AUDIBLY READY GREEN LIGHTS WILL LIGHT WHEN PRESSURE HAS BUILT UP INDICATORS WILL DRIVE APPROXIMATELY TO THE INTITIAL CONTROL SETTINGS
	NOTE: IF ANY OF THE RED WARNING LAMPS SHOULD ILLUMINATE, CALL AN INSTRUCTOR.	

STEP 6

LEAK CHECK OF THE TTU-205C/E

Follow procedures column for dial and switch settings, observe and compare normal indications column with actual indications. Check S or U for satisfactory or unsatisfactory completion of this area. Before performing the leak check, hook up hoses to tester to supply pneumatic pressures for the test bench.

	PROCEDURE	INDICATION
1	SET PTTS ALTITUDE TO 10,000 FEET AND AIRSPEED TO 625 KNOTS	ALTITUDE AND AIRSPEED INDICATORS WILL STABILIZE
2	SET LEAK TEST ALT. SWITCH TO ON	LEAK RATE IS LESS THAN 300 FEET IN TWO (2) MINUTES ____S or ____U
3	SET LEAK TEST ALT. SWITCH TO OFF	WAIT FOR GREEN READY LAMPS TO ILLUMINATE AND ALLOW ALTITUDE TO STABILIZE
4	SET ALTITUDE TO 0 FEET	ALLOW TO STABILIZE
5	SET LEAK TEST AIRSPEED SWITCH TO ON	LEAK RATE IS LESS THAN 3 KNOTS IN ONE (1) MINUTE
6	SET LEAK TEST AIRSPEED SWITCH TO OFF	WAIT FOR GREEN READY LAMPS TO ILLUMINATE AND ALLOW AIRSPEED TO STABILIZE ____S or ____U

STEP 7

ALTITUDE HOLD OUTPUT TEST

Follow procedures column for dial and switch settings, observe and compare normal indications column with actual indications. Check S or U for satisfactory or unsatisfactory completion of each area.

	PROCEDURE	INDICATION
1	SET ADCTS VTVM INPUT SWITCH TO Δ ALT	
2	SET PNEUMATIC MAINIFOLD CONTROL (PR) TO VENT	
3	SET PTTS ALTITUDE TO -10 TO 10 FEET AND AIRSPEED TO 70 TO 80 KNOTS	
4	SET ADCTS VTVM RANGE SWITCH TO 3 NOTE: VTVM and phase meter null at the same time. Either is used for nulling. If VTVM is used, the phase meter will indicate the direction of the control rotation required to null.	
5	VARY TAS-SPC COMMAND AC-DC RATIO CONTROL FOR NULL ON PHASE METER AND VTVM. RECORD SETTING HERE .	TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING IS BETWEEN 4930 TO 5070 _____S or _____U
6	SET VTVM RANGE SWITCH TO 30	
7	SET PTTS ALTITUDE TO 0 FEET AND AIRSPEED TO 145 and 155 KNOTS	
8	SET PTTS ALTITUDE HOLD SWITCH TO ALTITUDE HOLD AFTER STABILIZATION	
9	SET ADCTS VTVM RANGE SWITCH TO .3 NOTE: Due to allowable stability tolerance for the Air Data Computer, Δ altitude output and static pressure input, the TAS-SPC Command AC-DC Ratio control null adjustment and readout must be accomplished within five (5) second period after the clutch switch is positioned to Δ Alt. After completing null adjustment, any changes in the VTVM indication thereafter, for any period of time up to 30 minutes, should not exceed 292 millivolts.	
10	SET ADCTS CLUTCH SWITCH TO Δ ALT., VARY TAS-SPC COMMAND AC-DC RATIO CONTROL FOR NULL ON VTVM AND PHASE METER RECORD SETTING HERE _____.	NULL OCCURS AT A TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING OF 4920 TO 5080. TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING IS WITHIN ± 0080 OF SETTING RECORDED. _____S or _____U

1496

	PROCEDURE	INDICATION
11	RECORD TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING HERE ____	
12	SET PTTS TTU-205C/E ALTITUDE SWITCH TO NORMAL	
13	SET PTTS ALTITUDE TO 180 FEET. DO NOT ALLOW OVERSHOOT TO EXCEED 10 FT.	
14	AFTER THE ALTITUDE STABILIZES SET THE ALTITUDE HOLD SWITCH TO THE ON POSITION	
15	SET ADCTS VTVM RANGE SWITCH TO 3	
16	NULL PHASE METER AND VTVM WITH TAS-SPC COMMAND AD-DC RATIO CONTROL	TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING IS 3312 TO 4532 ABOVE SETTING RECORDED _____S or _____U
~~17~~	~~SET VTVM SWITCH TO 10~~	
~~18~~	~~SET PTTS TTU-205C/E ALTITUDE SWITCH TO NORMAL~~	
~~19~~	~~SET PTTS ALTITUDE TO 180 FEET. DO NOT ALLOW OVERSHOOT TO EXCEED 10 FT.~~	
~~20~~	~~AFTER ALTITUDE STABILIZES, SET THE ALTITUDE HOLD SWITCH TO THE ON POSITION~~	
~~21~~	~~SET ADCTS VTVM RANGE SWITCH TO 3~~	
~~22~~	~~NULL PHASE METER AND VTVM WITH TAS-SPC COMMAND AC-DC RATIO CONTROL~~	TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING IS 3312 TO 4532 BELOW SETTING RECORDED
23	SET VTVM RANGE SWITCH TO 300	
24	SET PTTS TTU-205C/E ALTITUDE SWITCH TO NORMAL	
25	SET ADCTS CLUTCH SWITCH TO OFF	_____S or _____U

STEP 8

POTENTIOMETER, TAS SYNCHRO AND AAR (LnPs-41) OUTPUT TESTS

Follow procedures column for dial and switch settings, observe and compare normal indications column with actual indications. Place the letter S or U in the spaces provided to indicate whether the test was satisfactory or unsatisfactory.

PROCEDURE		INDICATION
1	SET THE PTTS ALTITUDE TO 0 FEET AND AIRSPEED TO 536 KNOTS	
2	SET PNEUMATIC MANIFOLD CONTROL (Pr) TO ON	SMPT OUTPUT PRESSURE GAUGE 90 TO 120 PSI
3	MOMENTARILY SET ADCTS SPC MODE SWITCH TO RESET	FAILSAFE LIGHT GOES OUT AND REMAINS OUT
4	SET DC RATIOMETER SWITCH TO AUTO	
5	SET TEMP°R CONTROL TO 587	
6	SET ANGLE OF ATTACK CONTROL TO -10	
7	OBSERVE AEUTS LnPs-41 ALTITUDE	-39 TO 39 FEET
8	READ TAS INDICATOR WHEN USING ADCTS	528 TO 544 KNOTS
9	SET TAS INDICATOR SWITCH TO ON	
10	SET VTVM INPUT SWITCH TO α T1	
11	VARY TAS-SPC COMMAND AC-DC RATIO CONTROL TO OBTAIN NULL INDICATION ON PHASE METER	TAS-SPC COMMAND AC-DC RATIO CONTROL IS SET FROM 4695 TO 4805
12	SET ANGLE OF ATTACK TO 20	
13	VARY TAS-SPC COMMAND AC-DC RATIO CONTROL TO OBTAIN NULL INDICATION ON PHASE METER	TAS-SPC COMMAND AC-DC RATIO CONTROL IS SET FROM 1175 TO 1285
14	SET RATIOMETER INPUT SWITCH TO POSITIONS LISTED ON NEXT PAGE. AT EACH POSITION OBSERVE RATIOMETER INDICATION AND RECORD RESULT IN SPACE PROVIDED.	

	PROCEDURE	INDICATION
11	RECORD TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING HERE _____	
12	SET PTTS TTU-205C/E ALTITUDE SWITCH TO NORMAL	
13	SET PTTS ALTITUDE TO 180 FEET. DO NOT ALLOW OVERSHOOT TO EXCEED 10 FT.	
14	AFTER THE ALTITUDE STABILIZES SET THE ALTITUDE HOLD SWITCH TO THE ON POSITION	
15	SET ADCTS VTVM RANGE SWITCH TO 3	
16	NULL PHASE METER AND VTVM WITH TAS-SPC COMMAND AD-DC RATIO CONTROL	TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING IS 3312 TO 4532 ABOVE SETTING RECORDED _____S or _____U
~~17~~	~~SET VTVM SWITCH TO 10~~	
~~18~~	~~SET PTTS TTU-205C/E ALTITUDE SWITCH TO NORMAL~~	
~~19~~	~~SET PTTS ALTITUDE TO 180 FEET. DO NOT ALLOW OVERSHOOT TO EXCEED 10 FT.~~	
~~20~~	~~AFTER ALTITUDE STABILIZES, SET THE ALTITUDE HOLD SWITCH TO THE ON POSITION~~	
~~21~~	~~SET ADCTS VTVM RANGE SWITCH TO 3~~	
~~22~~	~~NULL PHASE METER AND VTVM WITH TAS-SPC COMMAND AC-DC RATIO CONTROL~~	TAS-SPC COMMAND AC-DC RATIO CONTROL SETTING IS 3312 TO 4532 BELOW SETTING RECORDED
23	SET VTVM RANGE SWITCH TO 300	
24	SET PTTS TTU-205C/E ALTITUDE SWITCH TO NORMAL	
25	SET ADCTS CLUTCH SWITCH TO OFF	_____S or _____U

	PROCEDURE	INDICATION
19	OBSERVE AEUTS LnPs-41 ALTITUDE	9941 TO 10,059 FEET
20	READ TAS INDICATOR	253 TO 269 KNOTS
21	SET ADCTS RATIOMETER INPUT SWITCH TO POSITIONS LISTED BELOW. AT EACH POSITION, OBSERVE RATIOMETER INDICATION AND RECORD RESULT IN SPACE PROVIDED	

Ratiometer Input	Min	Result	Max
Ps 2	1580		1652
Ps 40	6536		6600
LnPs 4	1164		1226
Qc 21	9164		9999
Qc 23	9497		9999
Hp 27	1853		1935
Hp 28	1853		1935
TAS 15	1695		1785
TAS 16	1695		1785
TAS 17	1677		1765
TAS 18	1695		1785
TAS 19	7718		8811
T_T 25	0000		0101
T_T 26	0000		0101
M 11	9331		9999

22	TEST SPARE OUTPUT 44 AS YOU DID IN PROCEDURE 15	1355 TO 1503

1500

	PROCEDURE	INDICATION
23	SET PTTS AIRSPEED TO 654 KNOTS	
24	SET ADCTS TEMP°R CONTROL TO 617	
25	READ TAS INDICATOR	730 TO 747 KNOTS
26	VARY TAS-SPC COMMAND RATIO CONTROL TO OBTAIN NULL ON PHASE METER	TAS-SPC COMMAND RATIO CONTROL SETTING IS SET FROM 1215 TO 1325
27	SET ANGLE OF ATTACK TO -10	
28	VARY TAS-SPC COMMAND RATIO CONTROL TO OBTAIN NULL ON PHASE METER	TAS-SPC COMMAND RATIO CONTROL SETTING IS FROM 5115 TO 5225
29	SET ADCTS RATIOMETER INPUT SWITCH TO POSITIONS LISTED BELOW. AT EACH POSITION, OBSERVE RATIOMETER INDICATION AND RECORD RESULT IN SPACE PROVIDED.	

Ratiometer Input	Min	Result	Max
Ps 2	1580		1652
Ps 40	6535		6600
LnPs 4	1164		1226
Qc 21	0065		1071
Qc 23	0000		0502
Hp 27	1853		1935
Hp 28	1853		1935
TAS 15	4875		4972
TAS 16	4875		4972
TAS 17	4826		4922
TAS 18	4875		4972
TAS 19	4550		5647
T_T 25	2162		2364
T_T 26	2162		2364
M 11	0000		0520

1501

	PROCEDURE	INDICATION
30	TEST SPARE OUTPUT 44 AS YOU DID IN PROCEDURE 15	1355 TO 1503
31	SET RATIOMETER SWITCH TO OFF	
32	SET VTVM INPUT SWITCH TO EXT.	
33	SET RATIOMETER INPUT SWITCH TO OFF	
34	SET PNEUMATIC MANIFOLD CONTROL (Pr) TO VENT	

STEP 9

Tt SWITCH (duct temp hi) TEST

	PROCEDURE	INDICATION
1	SET ADCTS TEMP°R CONTROL TO 705,	Tt 710° LIGHT OFF
	713,	ON
	711,	ON
	704	OFF

STEP 10

SHUT DOWN PROCEDURE

1. TTU-205C/E

	PROCEDURE	INDICATION
1	ROTATE THE AIRSPEED CONTROL TO 50 KNOTS	
2	ROTATE THE ALTITUDE CONTROL TO 740 FEET	
3	ALLOW PRESSURE TO STABILIZE, THEN OPEN Ps AND Pt EQUALIZER CONTROL	
4	SET POWER SWITCH TO OFF POSITION	

1561

2. AN/ASM-201B TEST BENCH

	PROCEDURE	INDICATION
1	CLOSE RED PRESSURE VALVE BEHIND TEST BENCH	
2	POSITION VACUUM PUMP SWITCH TO OFF	
3	TURN PNEUMATIC MANIFOLD VALVE (Pr) SWITCH TO OFF	
	NOTE: IF USING THE PITOT-STATIC CONTROL PANEL, BEFORE SHUTTING DOWN THE EQUIPMENT, INSURE THAT ALL PRESSURES ON THE CONTROL PANEL ARE VENTED OFF THE COMPUTER	

3. POWER SETTINGS

	PROCEDURE	INDICATION
1	SET ADCTS POWER SWITCH TO OFF	
2	SET AEUTS POWER SWITCH TO OFF	
3	SPC MODULE PNEUMATIC TESTER POWER SWITCH TO OFF	
4	PNEUMATIC REGULATOR POWER SWITCH TO OFF	
5	SET ALL SIX (6) CIRCUIT BREAKERS TO THE OFF POSITION	
6	DISCONNECT POWER CABLES	

HANDOUT

3ABR32531-HO-305

Technical Training

Avionics Instrument Systems Specialist

VERTICAL SCALE FLIGHT INSTRUMENTS

21 January 1980

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.
Do Not Use on the Job.

1504

Flight Training Device/Instrument Branch 3ABR32531-HO-305
Chanute AFB, Illinois

VERTICAL SCALE FLIGHT INSTRUMENTS

The schematic diagrams in this handout support the appropriate programmed texts and workbooks. They will be used by the students as directed by the instructor.

Glossary of Symbols and Abbreviations

1. Hp - Pressure altitude.
2. H$\dot{p}$ - Pressure altitude rate of change.
3. M - Mach.
4. MSM - Maximum Safe Mach.
5. MSMA - Maximum Safe Mach Assembly.
6. MSMf(q) - Maximum Safe Mach as a function of dynamic pressure.
7. MSMf(Tfat) - Maximum Safe Mach as a function of true freestream air temperature.
8. Ps - Statis pressure.
9. Psi - Indicated static pressure.
10. Pt - Total pressure or pitot pressure.
11. q - Dynamic.
12. Qci - Indicated differential static pressure.
13. Tfat - True freestream air temperature.
14. Ti - Total temperature.
15. Vc - Calibrated airspeed.
16. Vt - True airspeed.
17. α - Angle of attack.
18. αi - Indicated angle of attack.
19. αt - True angle of attack.
20. AOA - Angle of attack.
21. G - Gravity (G forces).
22. Hpr - Pressure altitude rate of change.
23. TAS - True airspeed.
24. —∧— - Wing sweep angle.

Note: Dynamic pressure is related to stress being applied to aircraft.

Supersedes 3ABR32531-HO-304, 3ABR32632B-HO-404, 8 November 1976, which may be used until existing stock is exhausted.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 300; TTVSA - 1

1564

PRIMARY PACKAGE

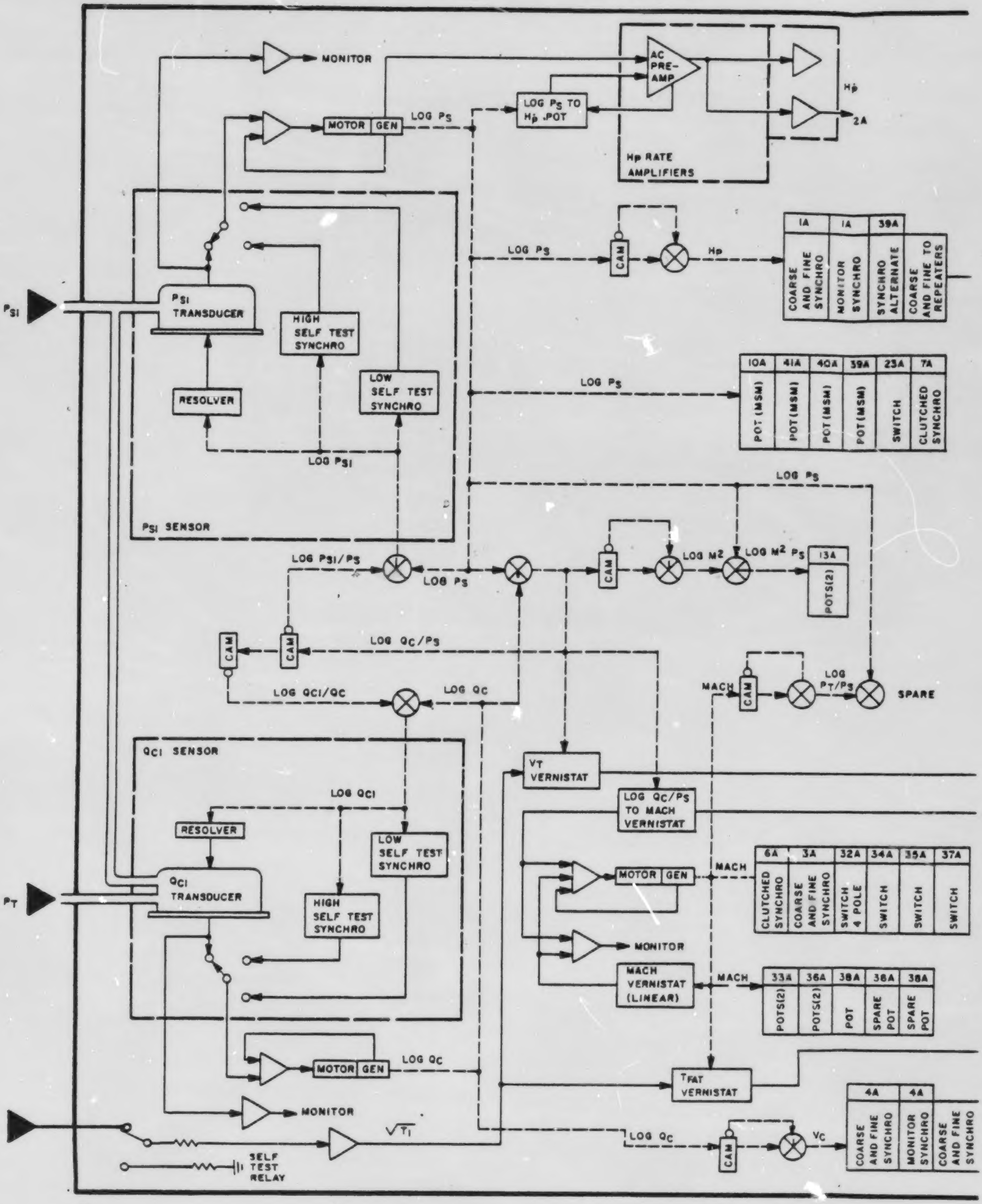
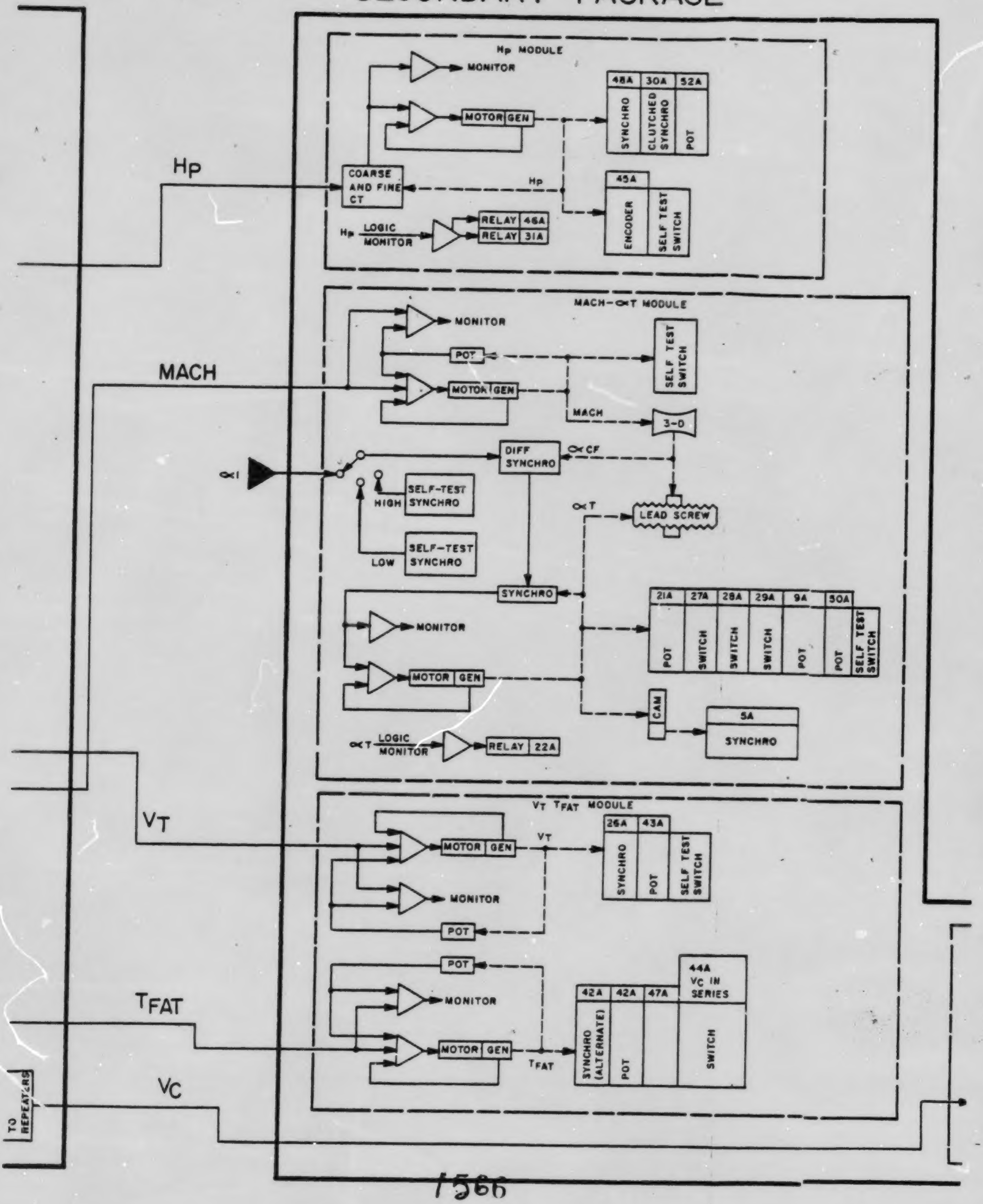

MONITOR
AC PRE-AMP
LOG P_S TO H_p POT
MOTOR
GEN
LOG P_S
H_p
2A
H_p RATE AMPLIFIERS
CAM
H_p
1A
1A
39A
COARSE AND FINE SYNCHRO
MONITOR SYNCHRO
SYNCHRO ALTERNATE
COARSE AND FINE TO REPEATERS
10A
41A
40A
39A
23A
7A
POT (MSM)
POT (MSM)
POT (MSM)
POT (MSM)
SWITCH
CLUTCHED SYNCHRO
P_{SI}
P_{SI} TRANSDUCER
HIGH SELF TEST SYNCHRO
LOW SELF TEST SYNCHRO
RESOLVER
LOG P_{SI}
P_{SI} SENSOR
LOG P_{SI}/P_S
LOG M^2
LOG M^2 P_S
13A
POTS(2)
LOG Q_C/P_S
LOG Q_{CI}/Q_C
LOG Q_C
MACH
LOG P_T/P_S
SPARE
Q_{CI} SENSOR
LOG Q_{CI}
V_T VERNISTAT
LOG Q_C/P_S TO MACH VERNISTAT
Q_{CI} TRANSDUCER
P_T
6A
3A
32A
34A
35A
37A
CLUTCHED SYNCHRO
COARSE AND FINE SYNCHRO
SWITCH 4 POLE
SWITCH
SWITCH
SWITCH
MACH VERNISTAT (LINEAR)
33A
36A
38A
38A
38A
POTS(2)
POTS(2)
POT
SPARE POT
SPARE POT
T_{FAT} VERNISTAT
T_I
$\sqrt{T_I}$
SELF TEST RELAY
V_C
4A
4A
COARSE AND FINE SYNCHRO
MONITOR SYNCHRO
COARSE AND FINE SYNCHRO

Figure 1, Section 1

1506

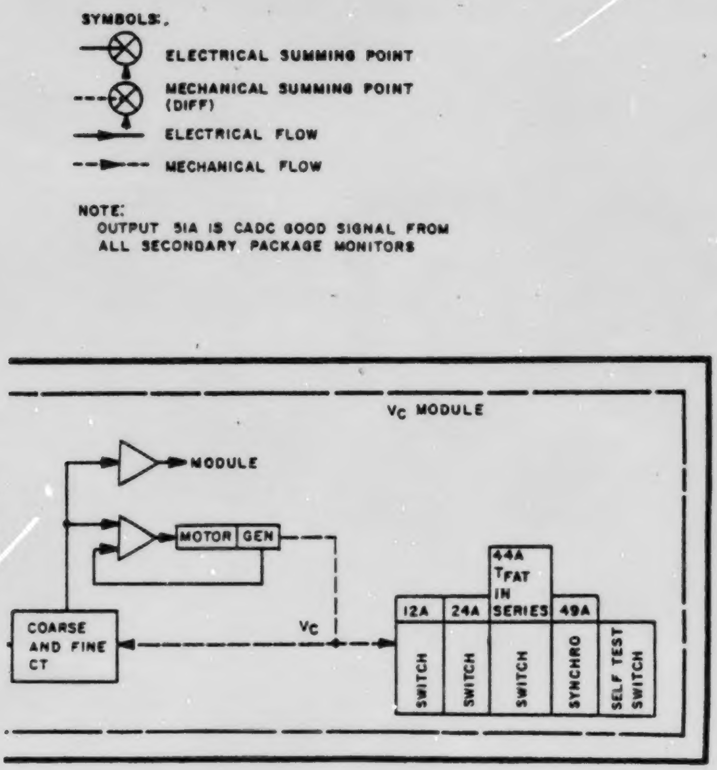
Figure 1, Section 2

SECONDARY PACKAGE


Hp MODULE
MONITOR
MOTOR GEN
48A
30A
52A
SYNCHRO
CLUTCHED SYNCHRO
POT
Hp
COARSE AND FINE CT
Hp
45A
ENCODER
SELF TEST SWITCH
Hp LOGIC MONITOR
RELAY 46A
RELAY 31A
MACH
MACH-∝T MODULE
MONITOR
POT
SELF TEST SWITCH
MOTOR GEN
MACH
3-D
∝I
DIFF SYNCHRO
∝CF
HIGH
SELF-TEST SYNCHRO
∝T
LEAD SCREW
LOW
SELF-TEST SYNCHRO
SYNCHRO
21A
27A
28A
29A
9A
50A
POT
SWITCH
SWITCH
SWITCH
POT
POT
SELF TEST SWITCH
MONITOR
MOTOR GEN
CAM
5A
SYNCHRO
∝T LOGIC MONITOR
RELAY 22A
VT
VT TFAT MODULE
VT
MOTOR GEN
26A
43A
SYNCHRO
POT
SELF TEST SWITCH
MONITOR
POT
POT
44A
VC IN SERIES
TFAT
MONITOR
42A
42A
47A
SYNCHRO (ALTERNATE)
POT
SWITCH
MOTOR GEN
TFAT
VC
TO REPEATERS

1566

FIGURE I.
CADC (PRIMARY & SECONDARY PACKAGES) BLOCK DIA.


SYMBOLS:
ELECTRICAL SUMMING POINT
MECHANICAL SUMMING POINT (DIFF)
ELECTRICAL FLOW
MECHANICAL FLOW
V_C MODULE
MODULE
MOTOR
GEN
COARSE AND FINE CT
V_C
12A
24A
44A T_{FAT} IN SERIES
49A
SWITCH
SWITCH
SWITCH
SYNCHRO
SELF TEST SWITCH

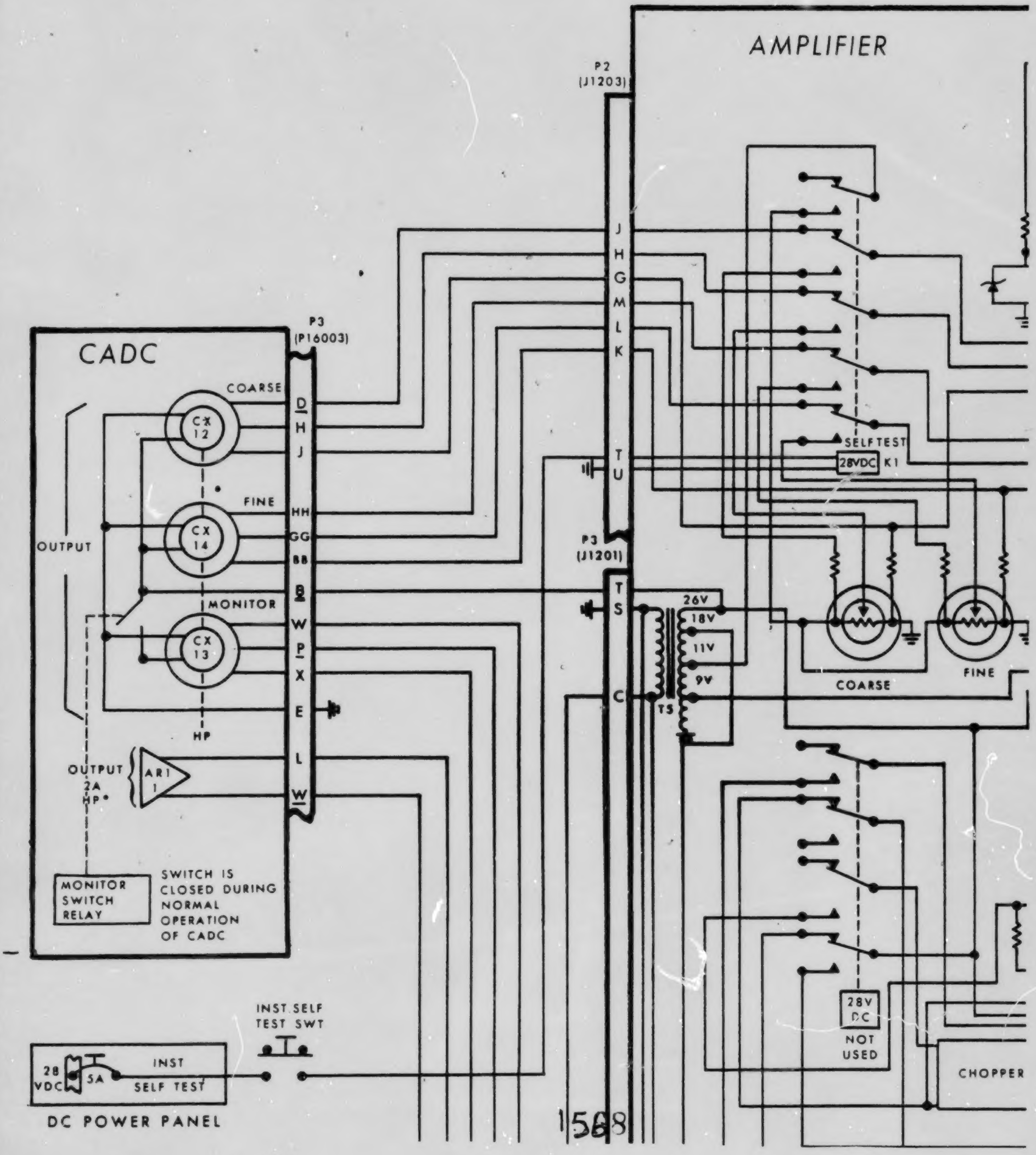
NOTE:
OUTPUT 51A IS CADC GOOD SIGNAL FROM ALL SECONDARY PACKAGE MONITORS

Figure 1. Central Air Data Computer Block Diagram.

Section 3

Figure 2, Section 1

ALTITUDE VERTICAL


AMPLIFIER
P2
(J1203)
J
H
G
M
L
K
T
U
P3
(J1201)
T
S
C
26V
18V
11V
9V
TS
SELF TEST
28VDC
K1
COARSE
FINE
28V
DC
NOT
USED
CHOPPER
CADC
P3
(P16003)
COARSE
CX
12
D
H
J
FINE
CX
14
HH
GG
BB
OUTPUT
MONITOR
CX
13
B
W
P
X
E
HP
OUTPUT
2A
HP*
AR1
1
L
W
MONITOR
SWITCH
RELAY
SWITCH IS
CLOSED DURING
NORMAL
OPERATION
OF CADC
INST SELF
TEST SWT
28
VDC
5A
INST
SELF TEST
DC POWER PANEL

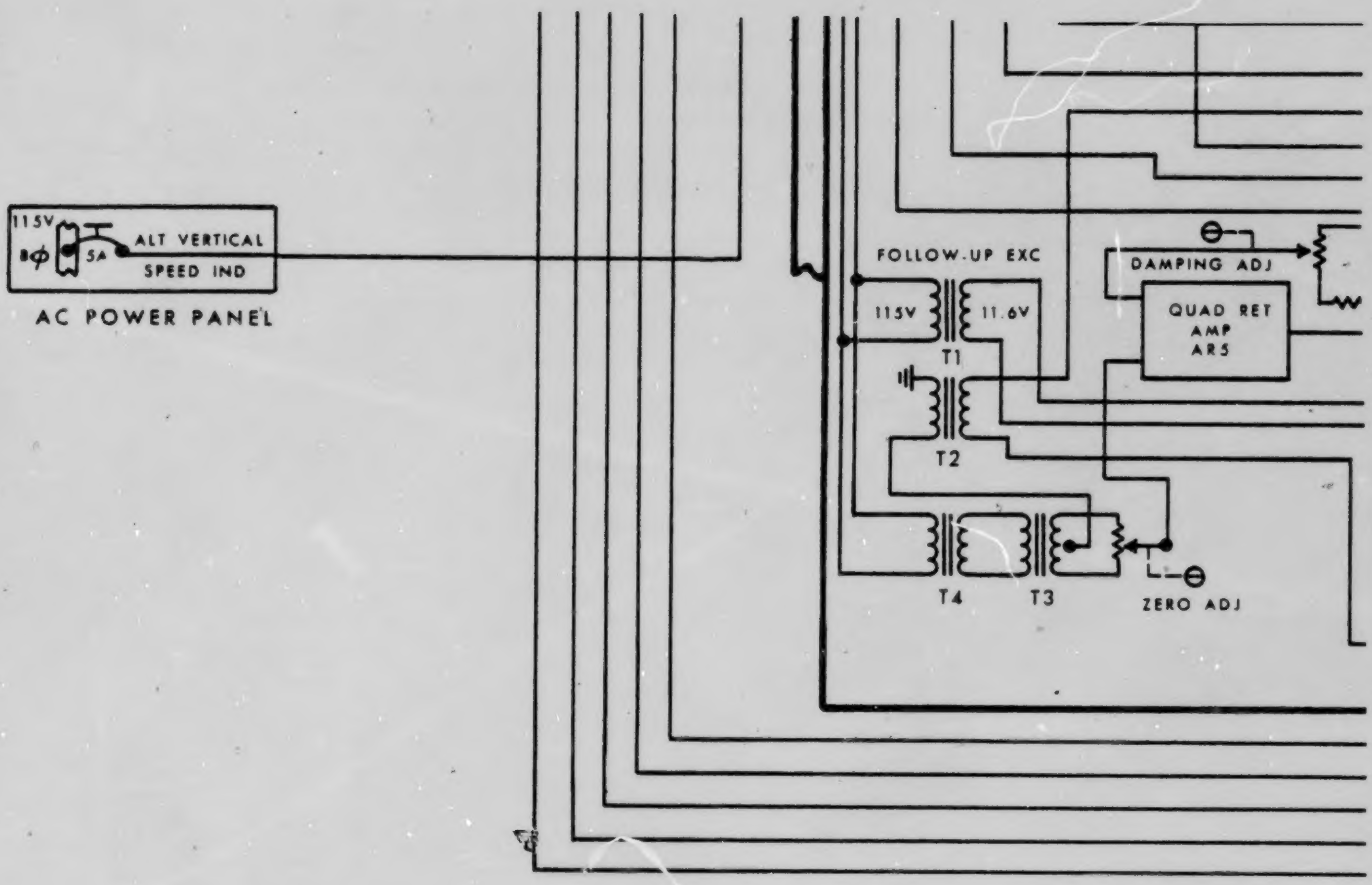

115V
3Φ
5A
ALT VERTICAL
SPEED IND
AC POWER PANEL
FOLLOW-UP EXC
115V
11.6V
T1
T2
T4
T3
ZERO ADJ
DAMPING ADJ
QUAD RET
AMP
AR5

Figure 2. Altitude Vertical Velocity Indicator.
Section 2

1510

VELOCITY INDICATOR

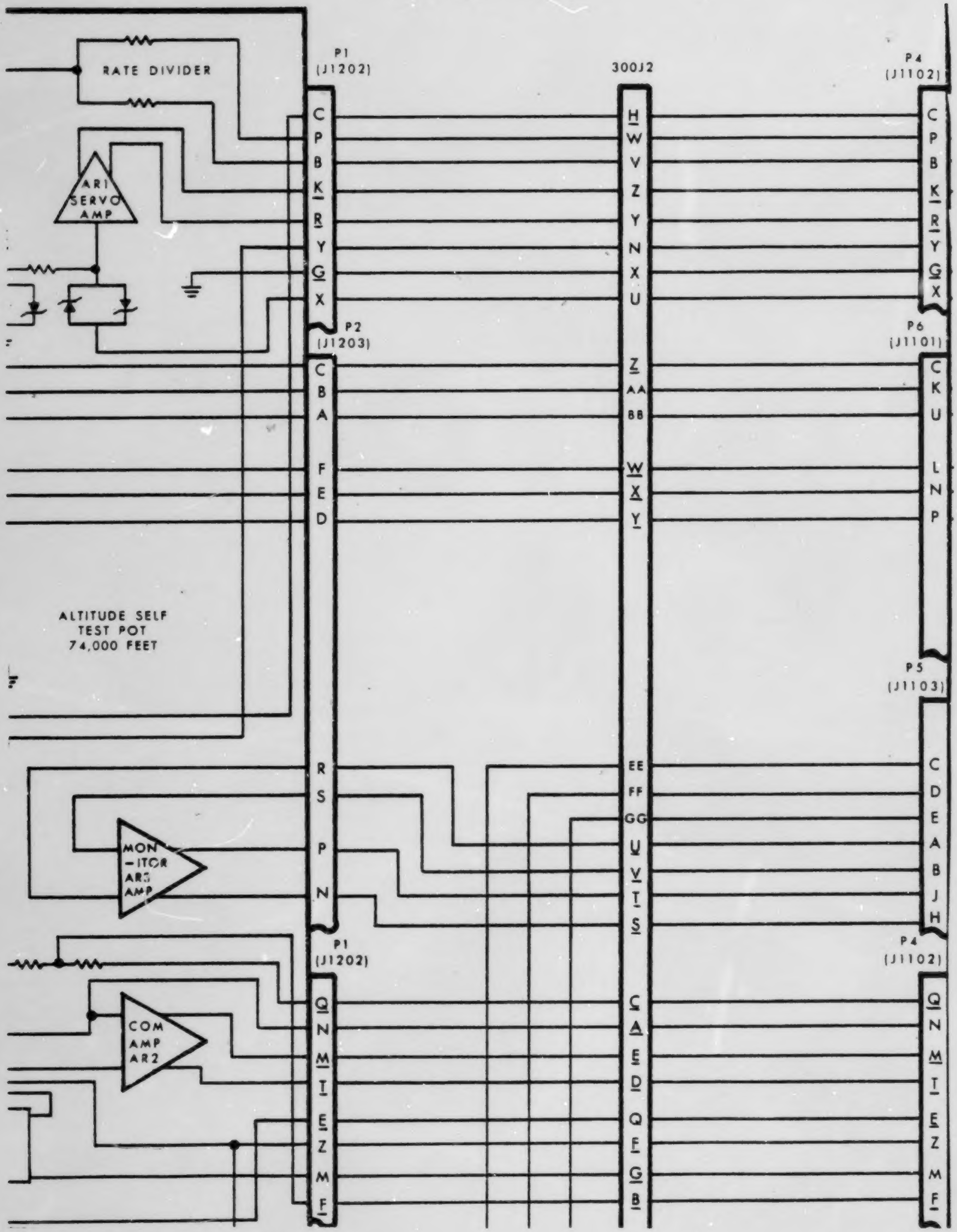

RATE DIVIDER
AR1 SERVO AMP
P1 (J1202)
300J2
P4 (J1102)
C P B K R Y G X
H W V Z Y N X U
C P B K R Y G X
P2 (J1203)
P6 (J1101)
C B A F E D
Z AA BB W X Y
C K U L N P
ALTITUDE SELF TEST POT 74,000 FEET
P5 (J1103)
R S P N
EE FF GG U V T S
C D E A B J H
MON-ITOR AR3 AMP
P1 (J1202)
P4 (J1102)
COM AMP AR2
Q N M T E Z M F
C A E D Q F G B
Q N M T E Z M F

Figure 2, Section 3

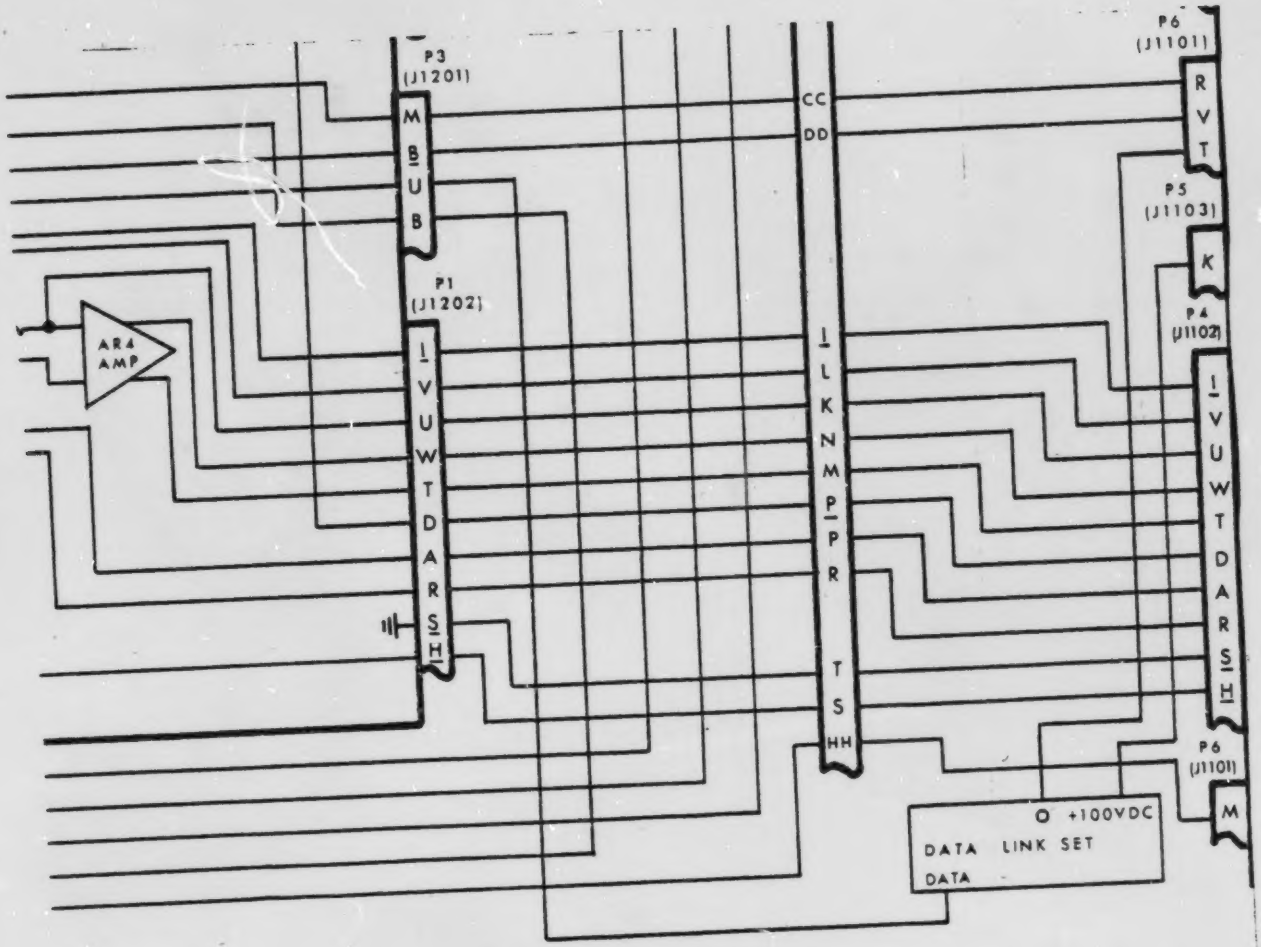

P3
(J1201)
M
B
U
B
P1
(J1202)
I
V
U
W
T
D
A
R
S
H
AR4
AMP
CC
DD
I
L
K
N
M
P
P
R
T
S
HH
P6
(J1101)
R
V
T
P5
(J1103)
K
P4
(J1102)
I
V
U
W
T
D
A
R
S
H
P6
(J1101)
M
O +100VDC
DATA LINK SET
DATA

Figure 2, Section 4

1512

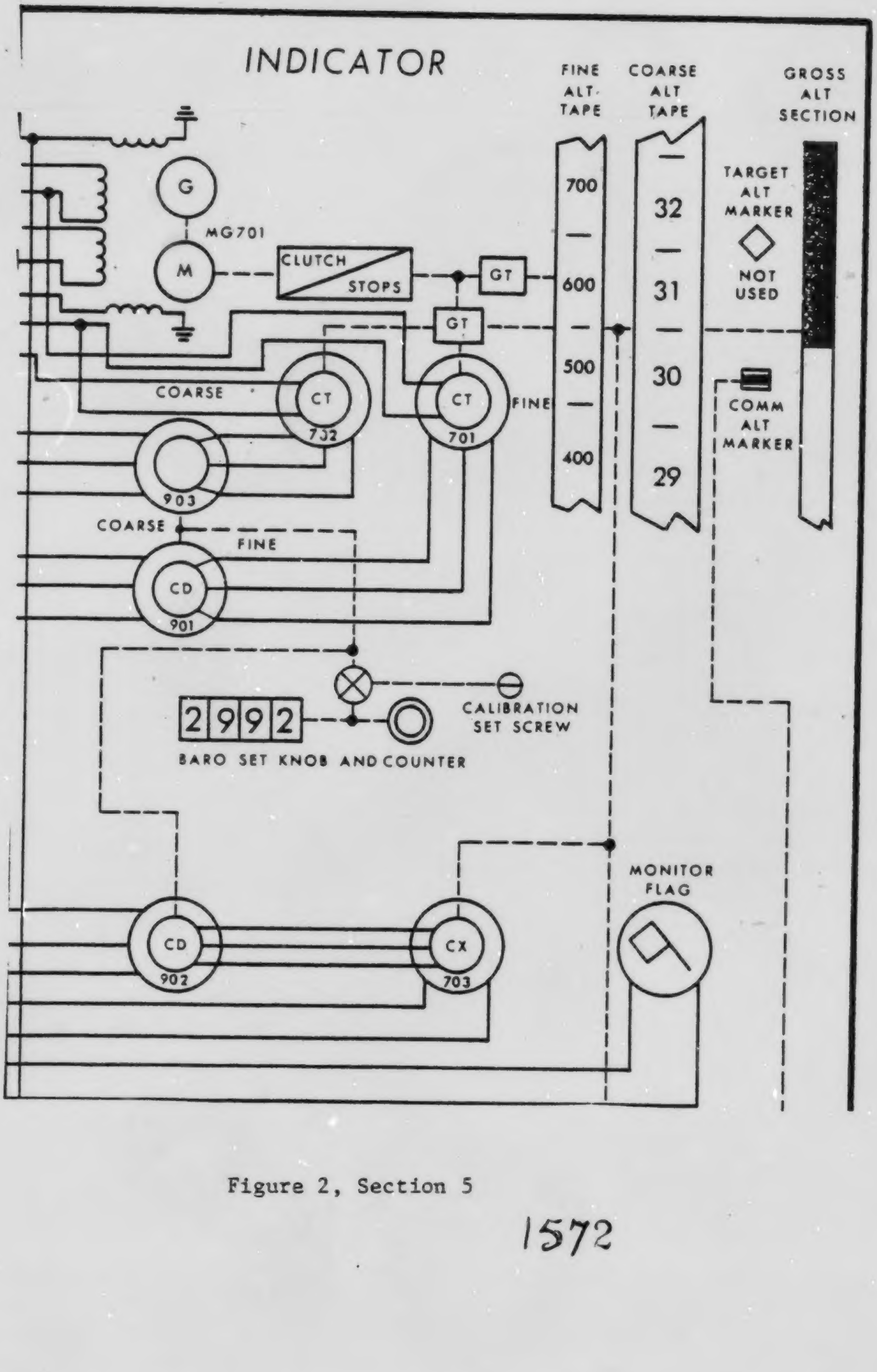

INDICATOR
FINE ALT TAPE
COARSE ALT TAPE
GROSS ALT SECTION
G
MG701
M
CLUTCH
STOPS
GT
GT
700
600
500
400
32
31
30
29
TARGET ALT MARKER
NOT USED
COMM ALT MARKER
COARSE
CT
732
CT
701
FINE
903
COARSE
FINE
CD
901
2992
CALIBRATION SET SCREW
BARO SET KNOB AND COUNTER
MONITOR FLAG
CD
902
CX
703

Figure 2, Section 5

1572

1513

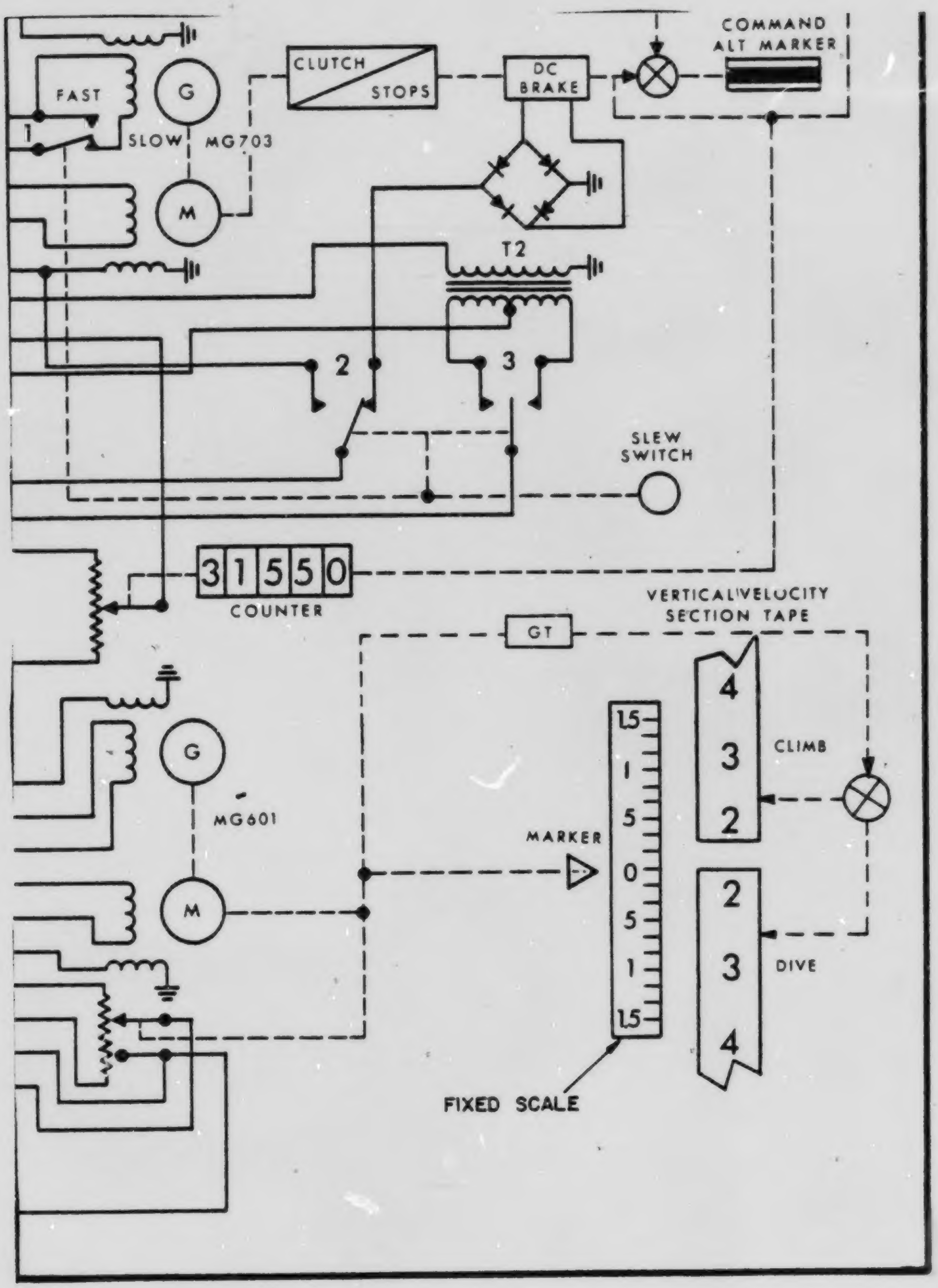
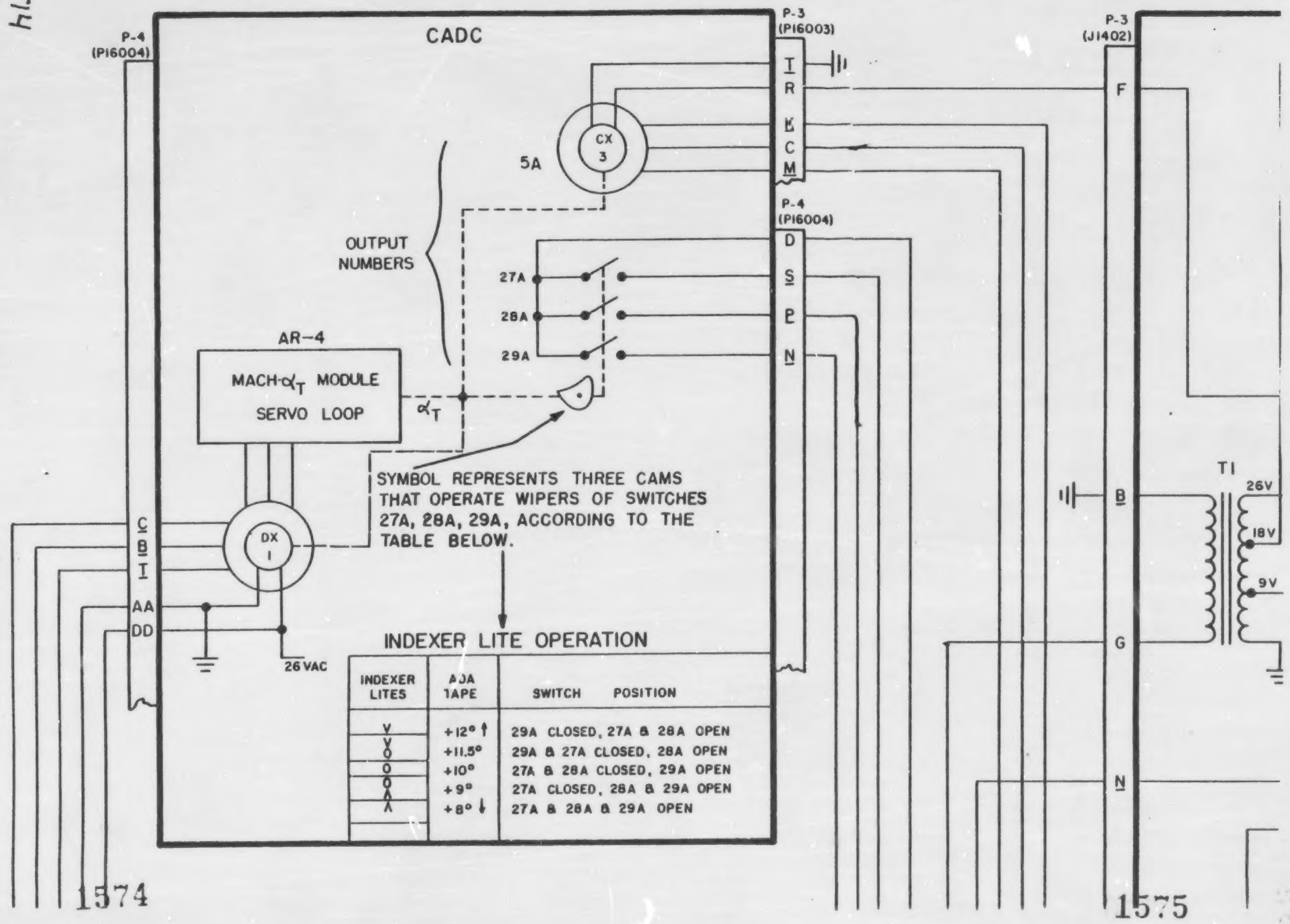

COMMAND ALT MARKER
CLUTCH
STOPS
DC BRAKE
FAST
G
1
SLOW
MG703
M
T2
2
3
SLEW SWITCH
31550
COUNTER
VERTICAL VELOCITY SECTION TAPE
GT
G
MG601
M
MARKER
1.5
1
5
0
5
1
1.5
4
3
2
CLIMB
2
3
4
DIVE
FIXED SCALE

Figure 2, Section 6

Figure 3, Section 1

AIRSPEED MACH INDICATOR AND INDEXER LITES

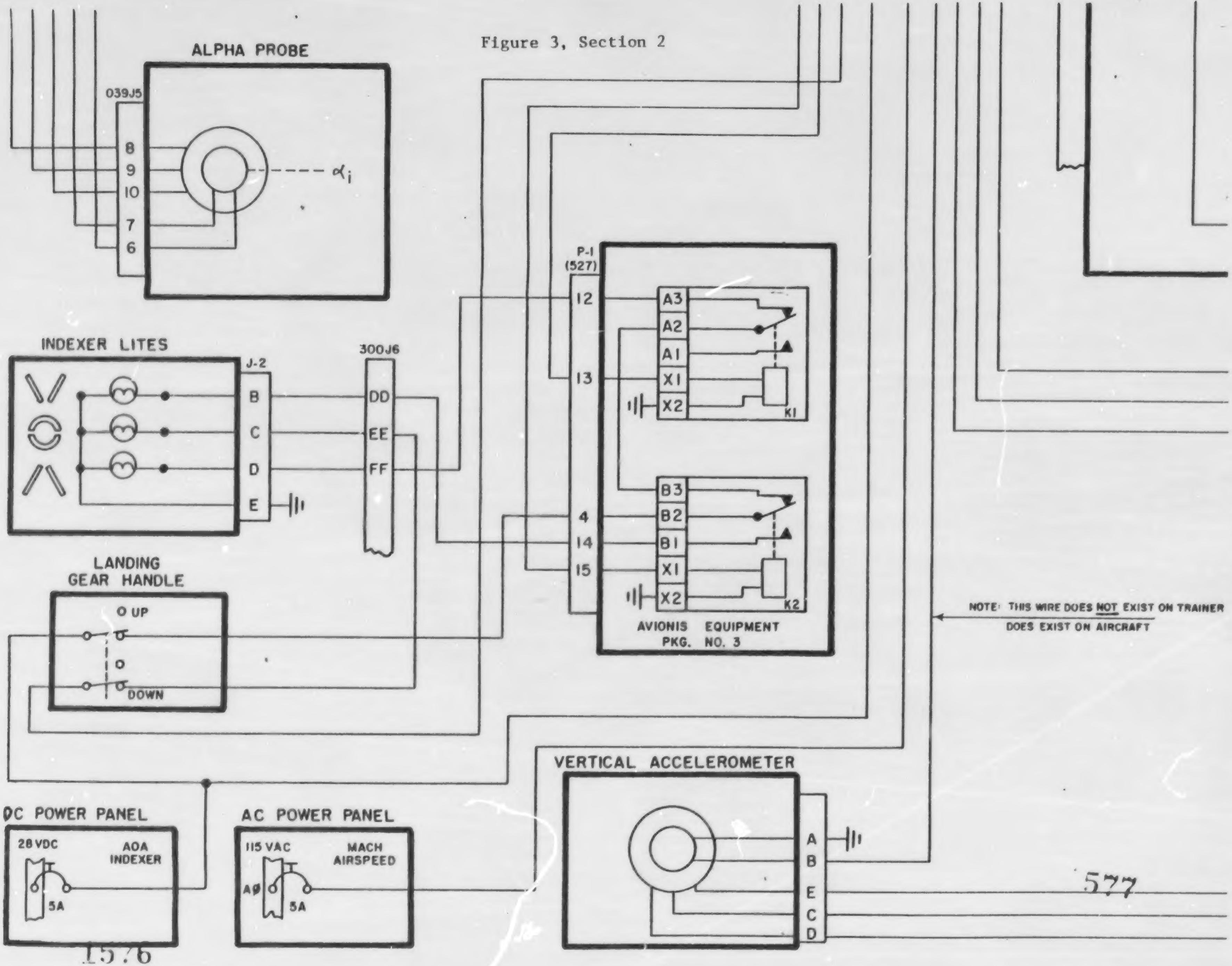
(ANGLE OF ATTACK AND "G" SECTIONS)


CADC
P-4
(P16004)
P-3
(P16003)
P-3
(J1402)
I
R
K
C
M
F
CX
3
5A
P-4
(P16004)
D
S
P
N
OUTPUT NUMBERS
27A
28A
29A
AR-4
MACH-α_T MODULE
SERVO LOOP
α_T
SYMBOL REPRESENTS THREE CAMS THAT OPERATE WIPERS OF SWITCHES 27A, 28A, 29A, ACCORDING TO THE TABLE BELOW.
C
B
I
AA
DD
DX
1
26 VAC
B
G
N
T1
26V
18V
9V

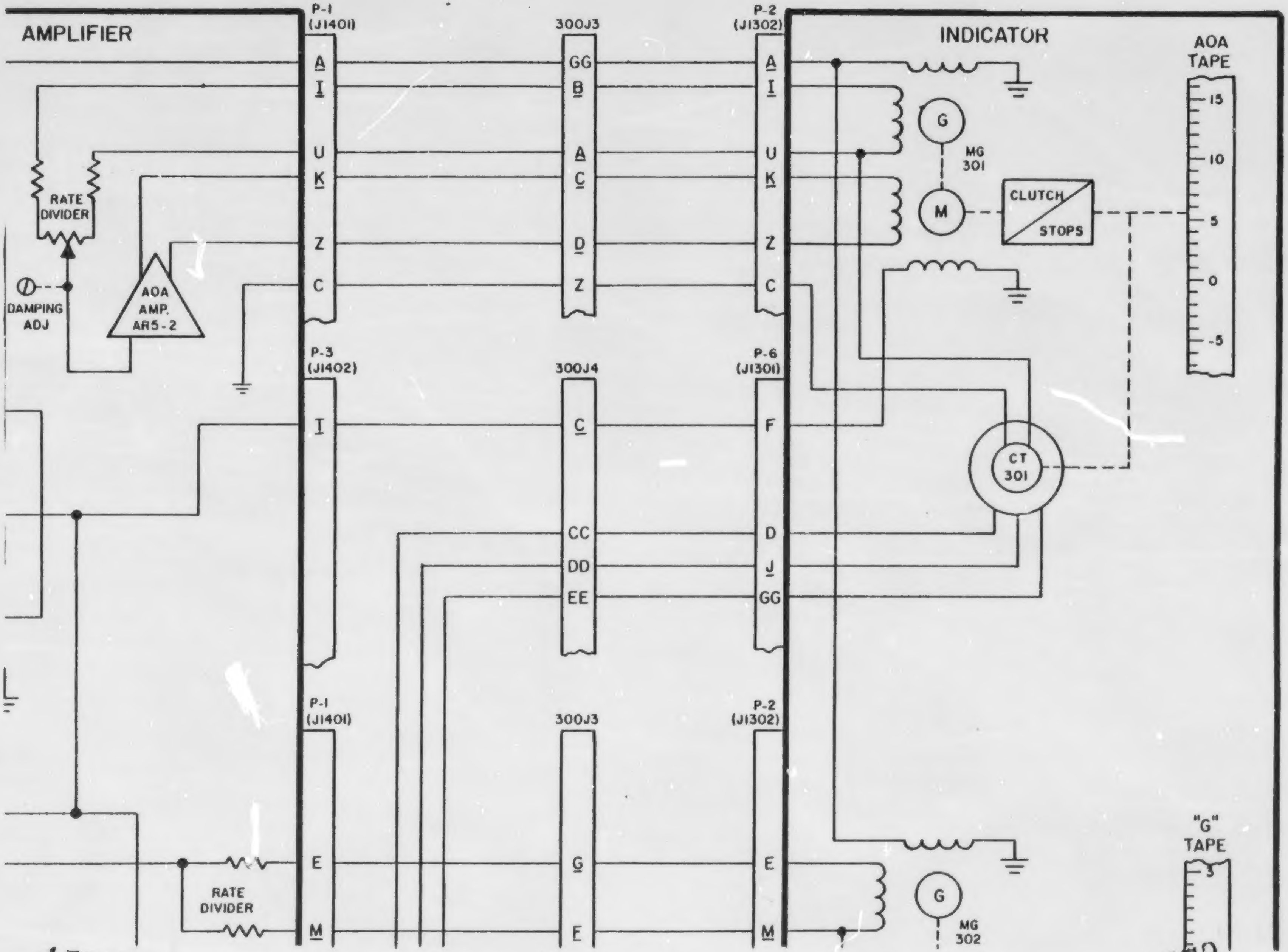
INDEXER LITE OPERATION

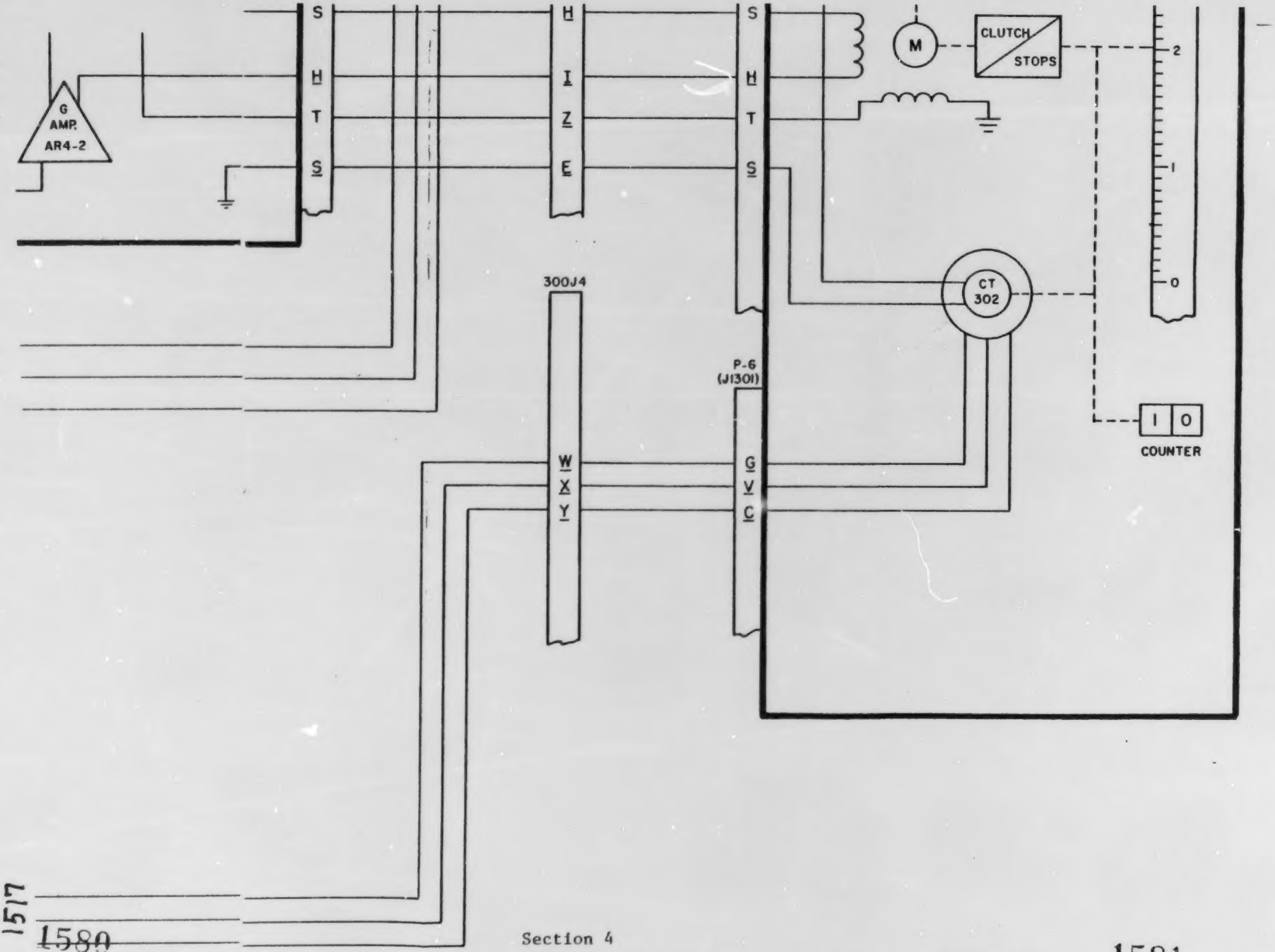
INDEXER LITES	AOA TAPE	SWITCH POSITION
V	+12° ↑	29A CLOSED, 27A & 28A OPEN
V O	+11.5°	29A & 27A CLOSED, 28A OPEN
O	+10°	27A & 28A CLOSED, 29A OPEN
O Λ	+9°	27A CLOSED, 28A & 29A OPEN
Λ	+8° ↓	27A & 28A & 29A OPEN

Figure 3, Section 2


ALPHA PROBE
039J5
8
9
10
7
6
α_i
INDEXER LITES
J-2
B
C
D
E
300J6
DD
EE
FF
LANDING GEAR HANDLE
UP
DOWN
P-1 (527)
12
13
4
14
15
A3
A2
A1
X1
X2
K1
B3
B2
B1
X1
X2
K2
AVIONIS EQUIPMENT PKG. NO. 3
DC POWER PANEL
28 VDC
AOA INDEXER
5A
AC POWER PANEL
115 VAC
AØ
5A
MACH AIRSPEED
VERTICAL ACCELEROMETER
A
B
E
C
D

NOTE: THIS WIRE DOES NOT EXIST ON TRAINER
DOES EXIST ON AIRCRAFT


AMPLIFIER
P-1
(J1401)
300J3
P-2
(J1302)
INDICATOR
AOA
TAPE
A
I
U
K
Z
C
GG
B
A
C
D
Z
15
10
5
0
-5
G
MG
301
M
CLUTCH
STOPS
RATE
DIVIDER
DAMPING
ADJ
AOA
AMP.
AR5-2
P-3
(J1402)
300J4
P-6
(J1301)
I
C
F
CT
301
CC
DD
EE
D
J
GG
P-1
(J1401)
300J3
P-2
(J1302)
E
G
E
M
F
M
RATE
DIVIDER
G
MG
302
"G"
TAPE
3


S
H
T
S
H
I
Z
E
S
H
T
S
G
AMP.
AR4-2
M
CLUTCH
STOPS
2
1
0
CT
302
300J4
P-6
(J1301)
W
X
Y
G
V
C
1 0
COUNTER

1517

~~1580~~

Section 4

Figure 3. Airspeed Mach Indicator and Indexer Lites.

AIRSPEED MACH INDICATOR
(MACH SECTION)

*ENERGIZES K'5 WHEN MSM f(^{T}FAT) IS GREATER THAN MSM f(q)
**ENERGIZES K4 WHEN ACTUAL MACH IS GREATER THAN COMPUTED MSM

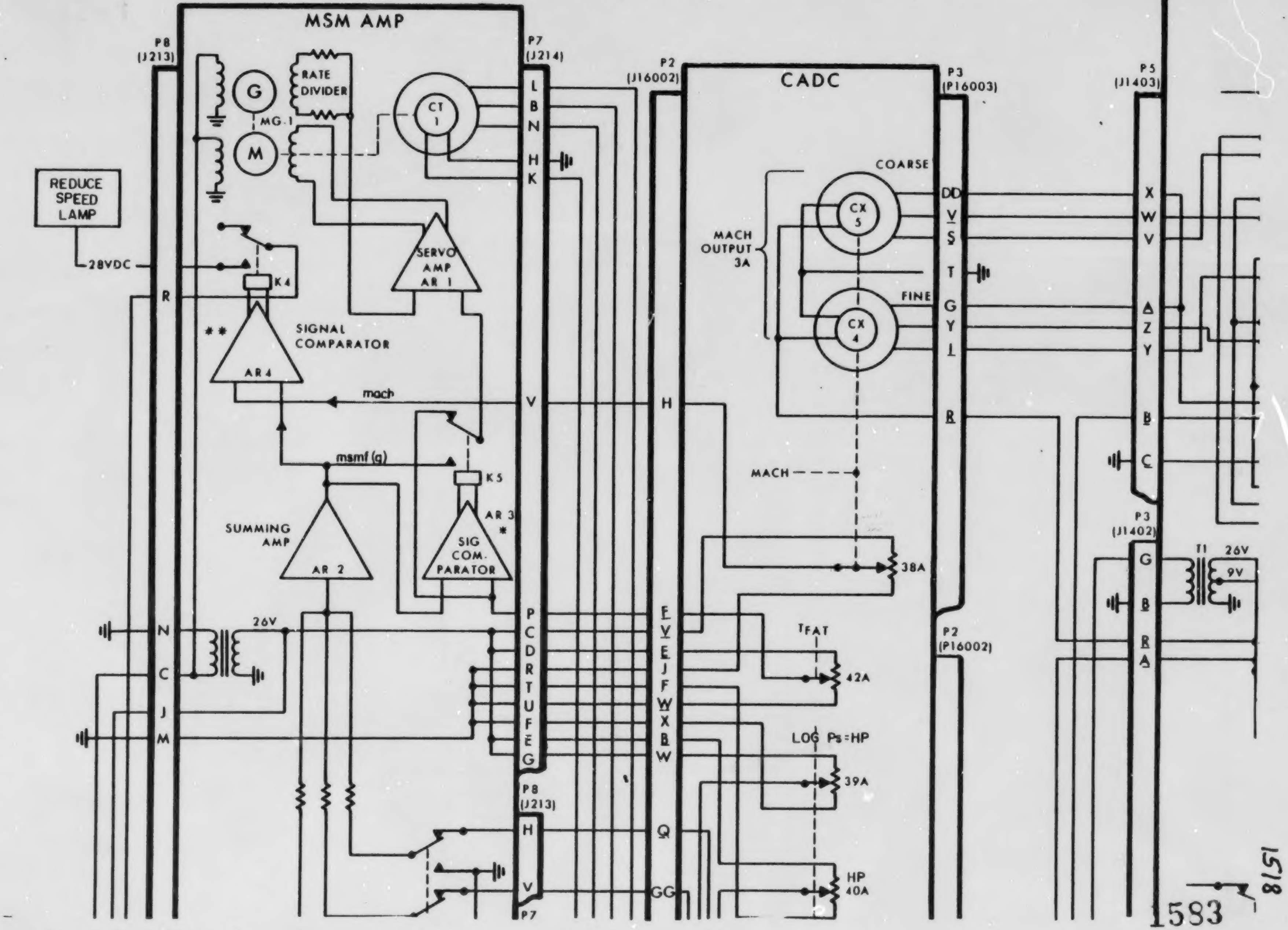

MSM AMP
P8 (J213)
P7 (J214)
RATE DIVIDER
G
M
MG.1
CT 1
L
B
N
H
K
REDUCE SPEED LAMP
28VDC
R
K4
SERVO AMP AR 1
**
SIGNAL COMPARATOR
AR 4
mach
V
msmf (q)
K5
AR 3
*
SUMMING AMP
AR 2
SIG COM-PARATOR
P
C
D
R
T
U
F
E
G
N
C
J
M
26V
P8 (J213)
H
V
P7
P2 (J16002)
CADC
P3 (P16003)
COARSE
MACH OUTPUT 3A
CX 5
CX 4
FINE
DD
V
S
T
G
Y
I
R
H
MACH
38A
F
V
E
J
F
W
X
B
W
TFAT
42A
LOG Ps=HP
39A
Q
GG
HP 40A
P2 (P16002)
P5 (J1403)
X
W
V
Δ
Z
Y
B
C
P3 (J1402)
G
B
R
A
T1
26V
9V

Figure 4, Section 1

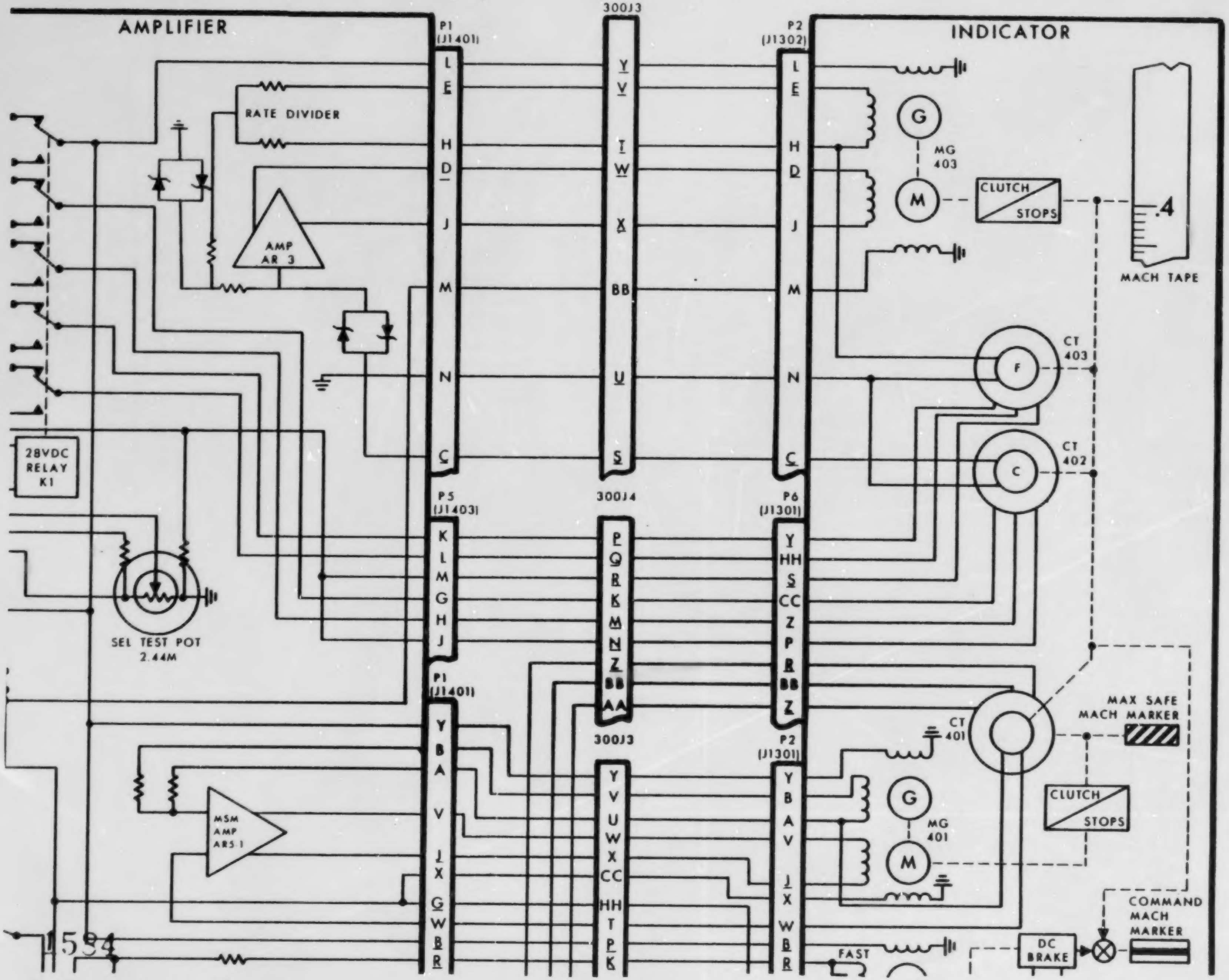
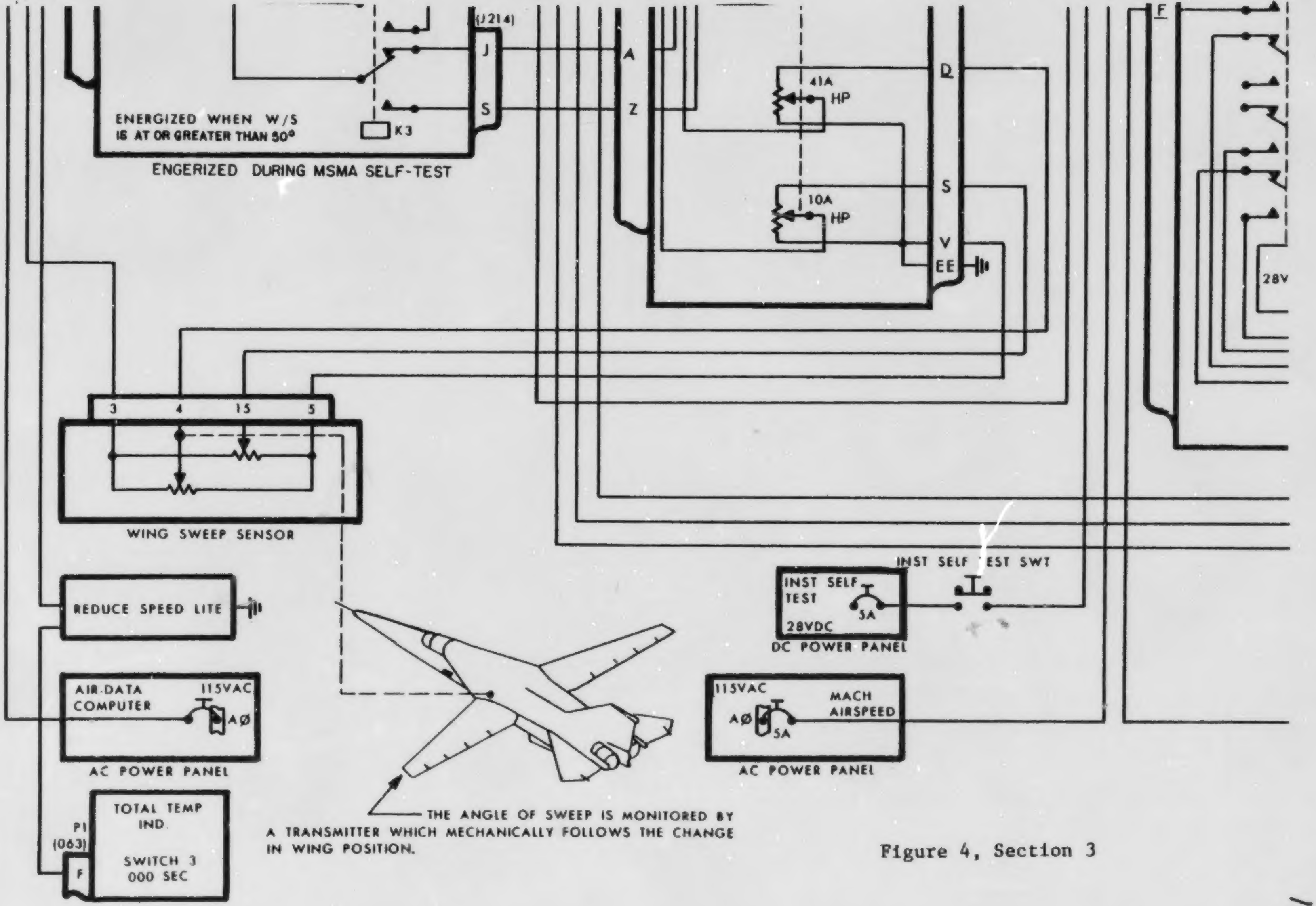

AMPLIFIER
RATE DIVIDER
AMP
AR 3
28VDC
RELAY
K1
SEL TEST POT
2.44M
MSM
AMP
ARS-1
P1
(J1401)
L
E
H
D
J
M
N
C
300J3
Y
V
T
W
X
BB
U
S
P2
(J1302)
L
E
H
D
J
M
N
C
P5
(J1403)
K
L
M
G
H
J
300J4
P
Q
R
K
M
N
Z
BB
AA
P6
(J1301)
Y
HH
S
CC
Z
P
R
BB
Z
P1
(J1401)
Y
B
A
V
J
X
G
W
B
R
300J3
Y
V
U
W
X
CC
HH
T
P
K
P2
(J1301)
Y
B
A
V
J
X
W
B
R
INDICATOR
G
M
MG
403
CLUTCH
STOPS
.4
MACH TAPE
CT
403
F
CT
402
C
CT
401
MAX SAFE
MACH MARKER
CLUTCH
STOPS
G
M
MG
401
FAST
DC
BRAKE
COMMAND
MACH
MARKER

Figure 4, Section 2


(J214)
J
S
A
Z
ENERGIZED WHEN W/S IS AT OR GREATER THAN 50°
K3
ENGERIZED DURING MSMA SELF-TEST
41A
HP
10A
HP
D
S
V
EE
F
28V
3
4
15
5
WING SWEEP SENSOR
REDUCE SPEED LITE
AIR-DATA COMPUTER
115VAC
AØ
AC POWER PANEL
TOTAL TEMP IND.
SWITCH 3 000 SEC
P1 (063)
F
INST SELF TEST SWT
INST SELF TEST
5A
28VDC
DC POWER PANEL
115VAC
AØ
5A
MACH AIRSPEED
AC POWER PANEL

THE ANGLE OF SWEEP IS MONITORED BY A TRANSMITTER WHICH MECHANICALLY FOLLOWS THE CHANGE IN WING POSITION.

Figure 4, Section 3

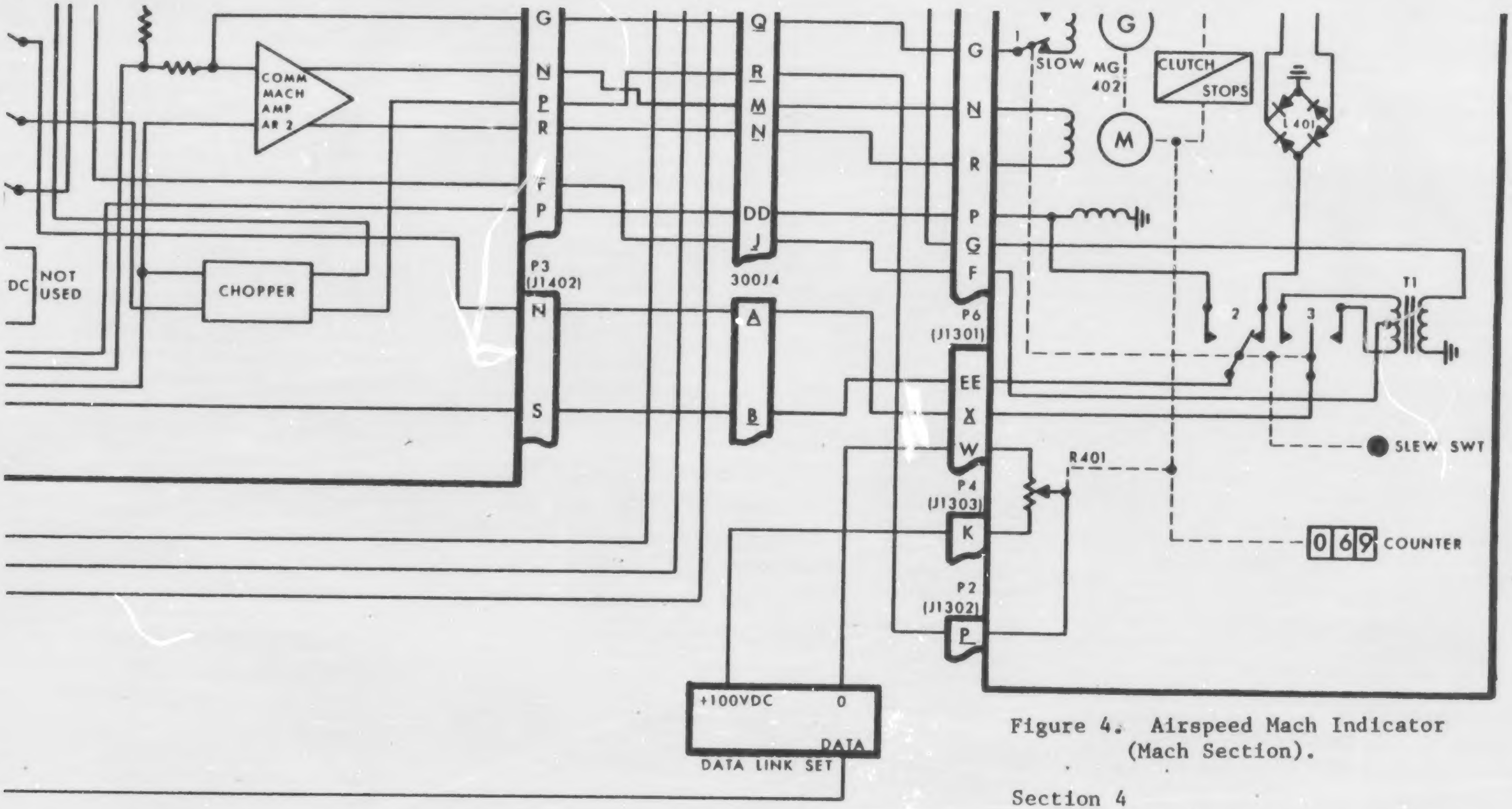

COMM MACH AMP AR 2
DC
NOT USED
CHOPPER
G
N
P
R
F
P
P3 (J1402)
N
S
Q
R
M
N
DD
J
300J4
A
B
G
N
R
P
G
F
P6 (J1301)
EE
X
W
P4 (J1303)
K
P2 (J1302)
P
1
SLOW
G
MG 402
M
CLUTCH
STOPS
L 401
2
3
T1
R401
SLEW SWT
0 6 9
COUNTER
+100VDC
0
DATA
DATA LINK SET

Figure 4. Airspeed Mach Indicator (Mach Section).

Section 4

AIRSPEED MACH INDICATOR
(AIRSPEED SECTION)

Figure 5, Section 1

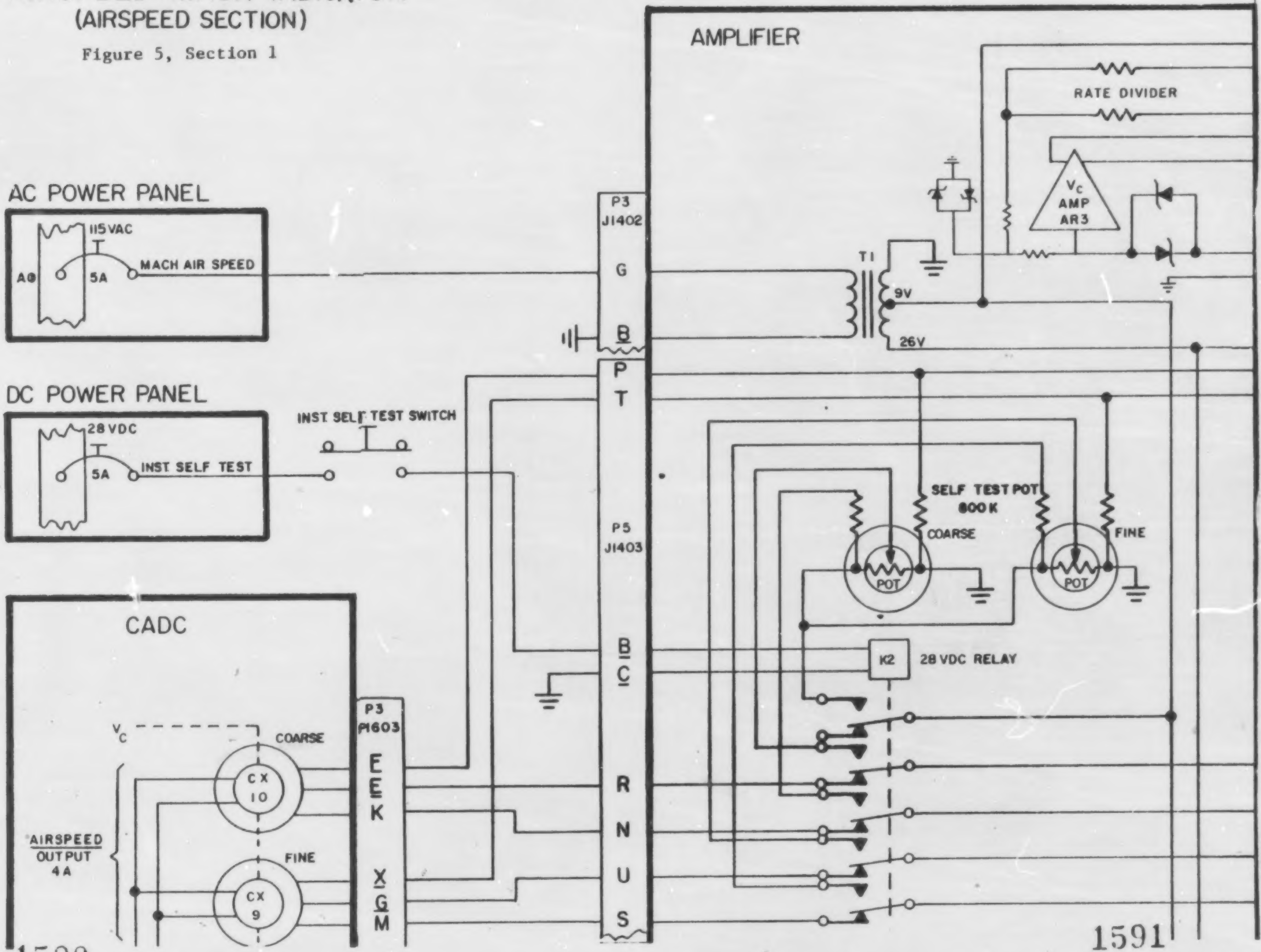
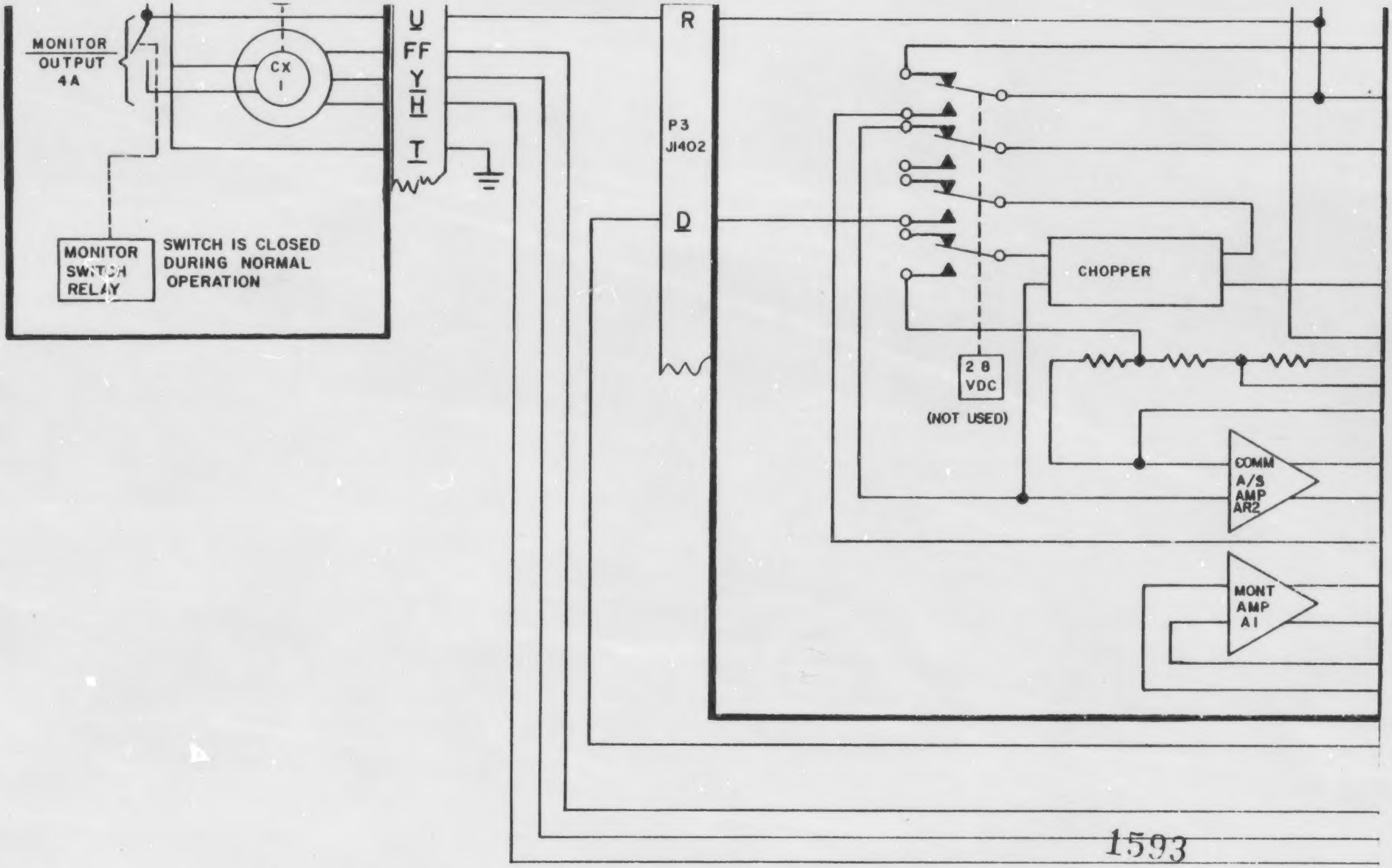

AMPLIFIER
RATE DIVIDER
V_C AMP AR3
T1
9V
26V
AC POWER PANEL
115 VAC
AØ
5A
MACH AIR SPEED
P3
J1402
G
B
P
T
DC POWER PANEL
28 VDC
5A
INST SELF TEST
INST. SELF TEST SWITCH
SELF TEST POT
800 K
COARSE
FINE
POT
POT
P5
J1403
B
C
K2
28 VDC RELAY
CADC
V_C
COARSE
CX 10
FINE
CX 9
AIRSPEED OUTPUT 4A
P3
P1603
E
E
K
X
G
M
R
N
U
S

Figure 5, Section 2


MONITOR OUTPUT 4A
CX 1
U
FF
Y
H
T
MONITOR SWITCH RELAY
SWITCH IS CLOSED DURING NORMAL OPERATION
R
P3 J1402
D
CHOPPER
28 VDC
(NOT USED)
COMM A/S AMP AR2
MONT AMP A1

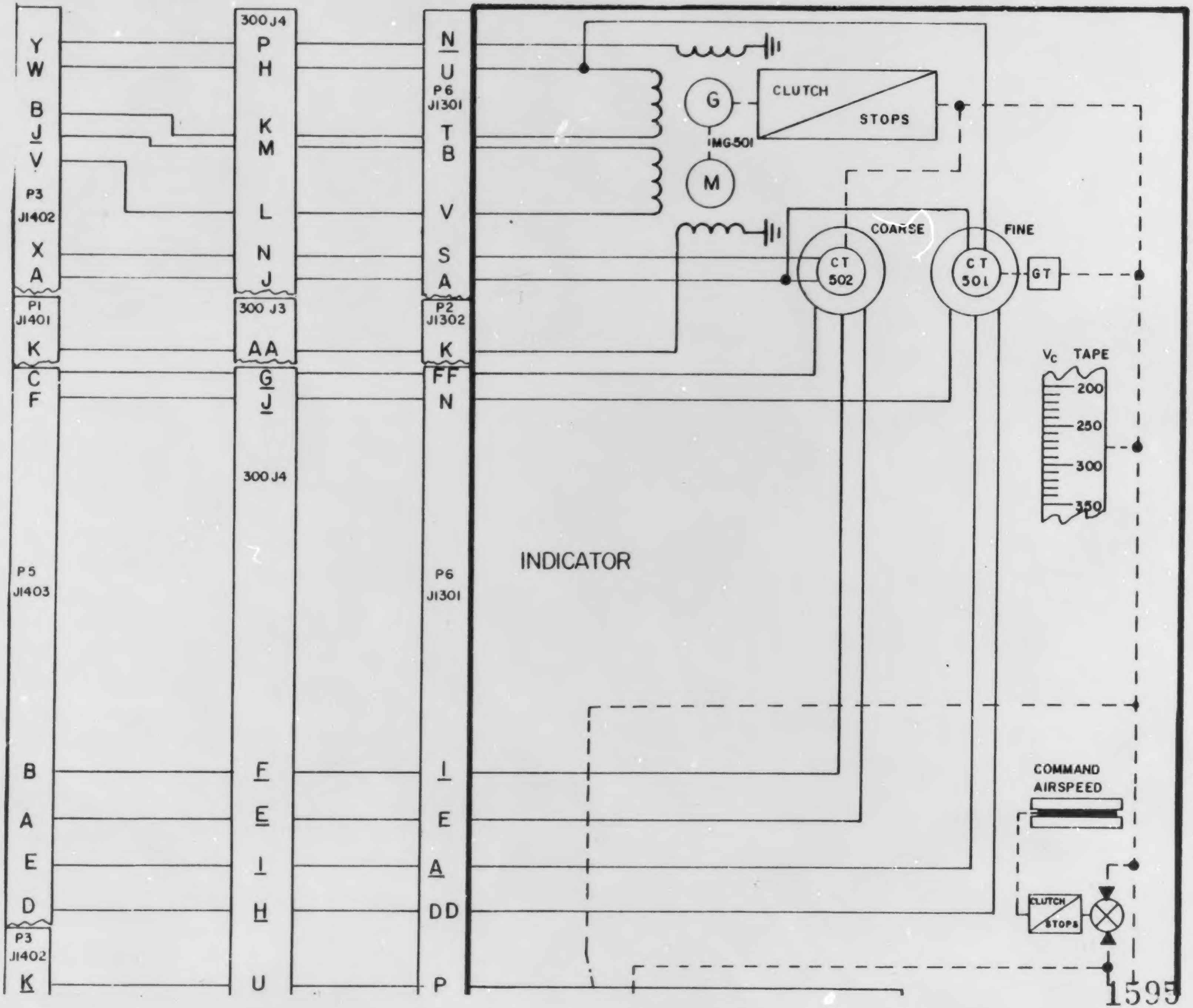
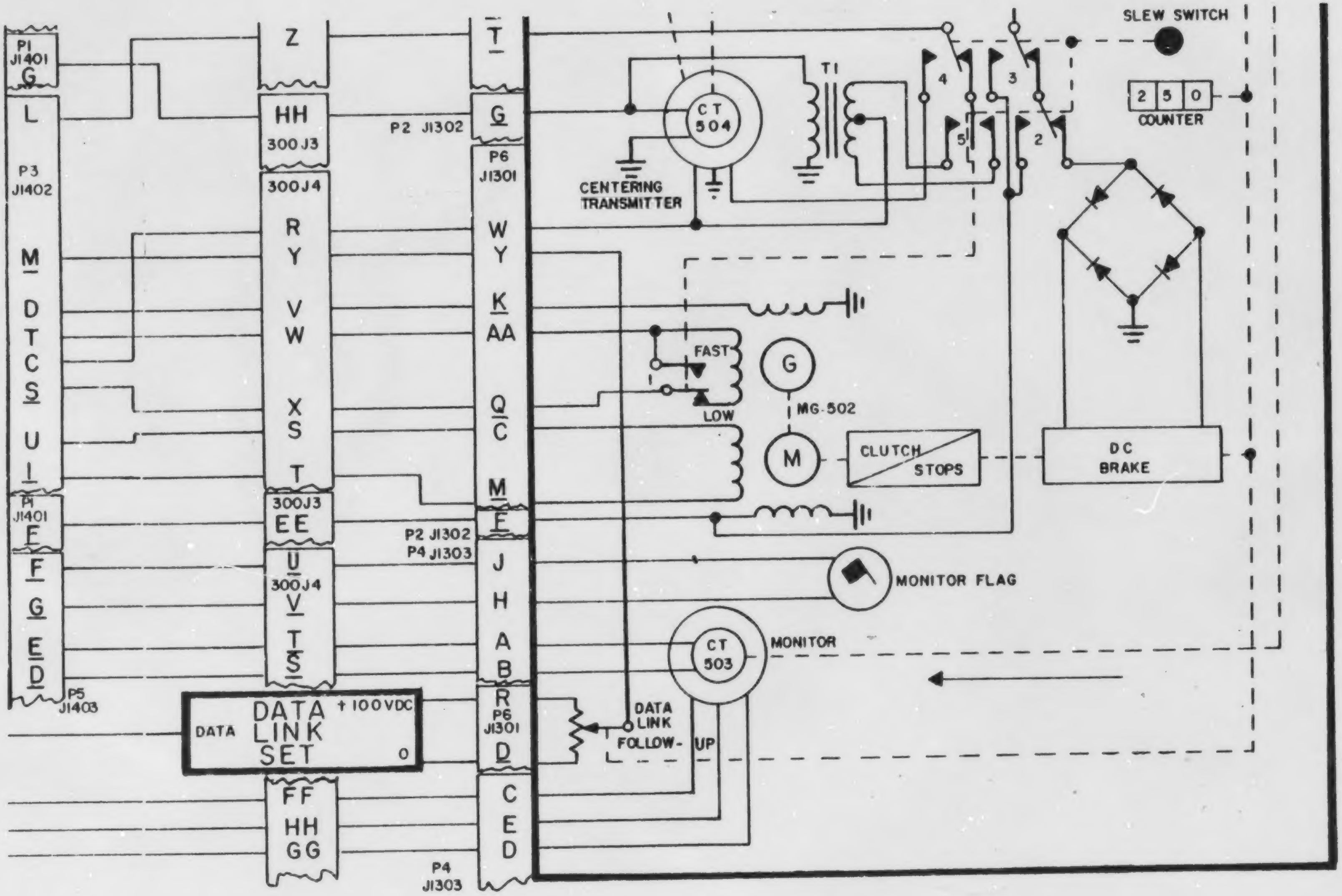

Y
W
B
J
V
P3
J1402
X
A
P1
J1401
K
C
F
P5
J1403
B
A
E
D
P3
J1402
K
300 J4
P
H
K
M
L
N
J
300 J3
AA
G
J
300 J4
F
E
I
H
U
N
U
P6
J1301
T
B
V
S
A
P2
J1302
K
FF
N
P6
J1301
I
E
A
DD
P
G
CLUTCH
STOPS
IMG501
M
COARSE
FINE
CT
502
CT
501
GT
V_C TAPE
200
250
300
350
INDICATOR
COMMAND
AIRSPEED
CLUTCH
STOPS

Figure 5, Section 3


P1
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G
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P3
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G
MG-502
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CLUTCH
STOPS
DC
BRAKE
MONITOR FLAG
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LINK
FOLLOW-UP

Figure 5. Airspeed Mach Indicator
Section 4

1526

TOTAL TEMP AND TRUE AIRSPEED

Figure 6, Section 1

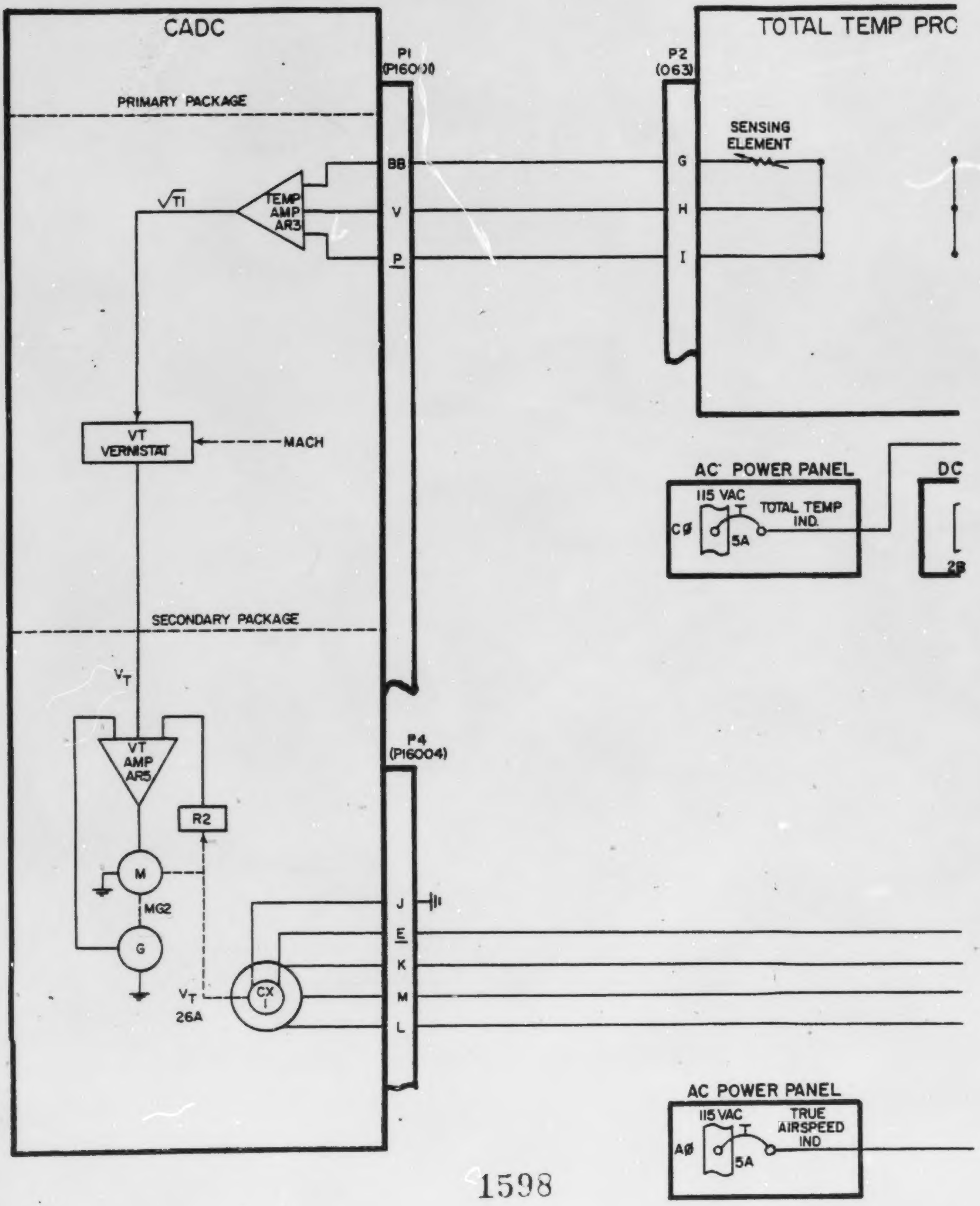

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Figure 6, Section 2

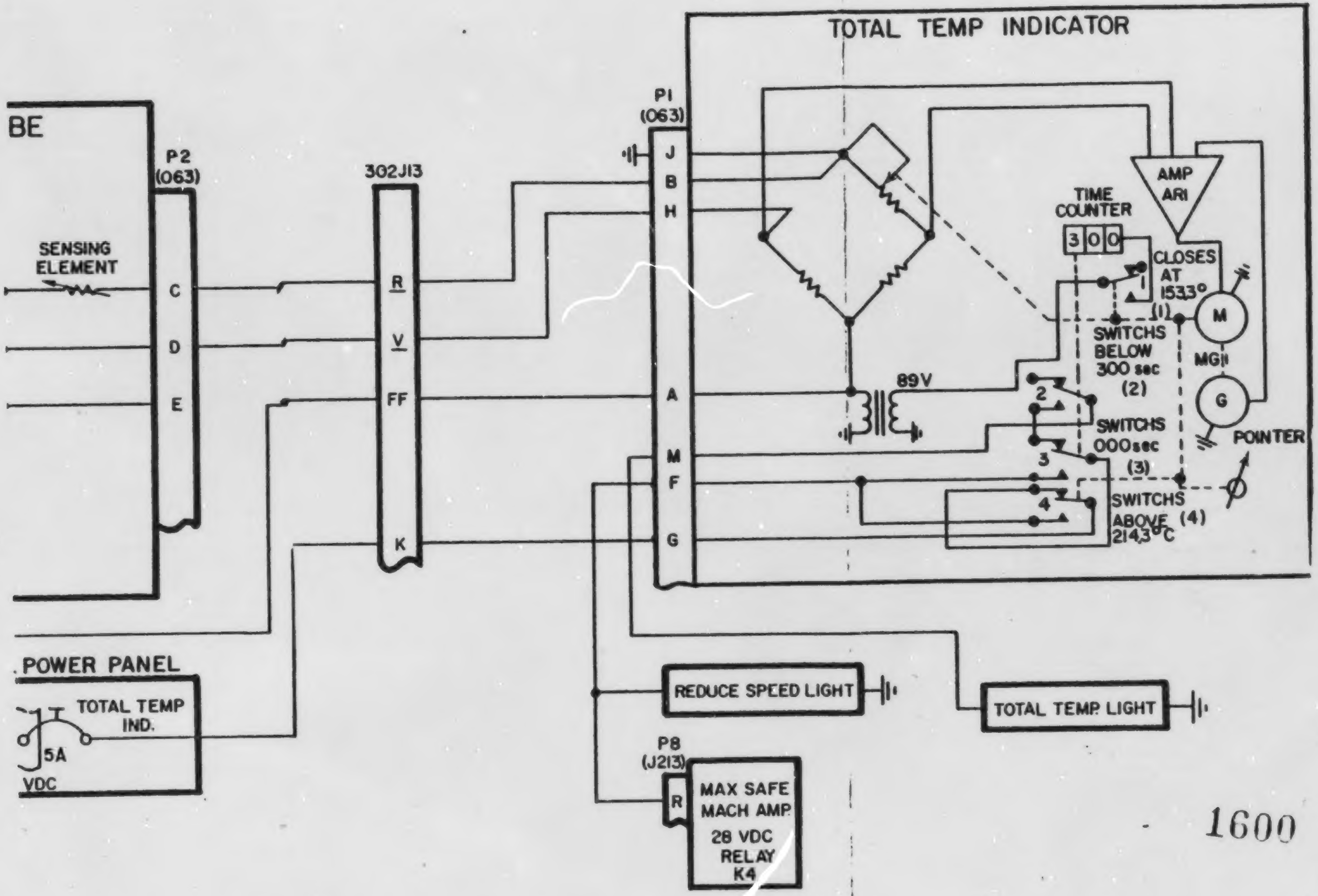
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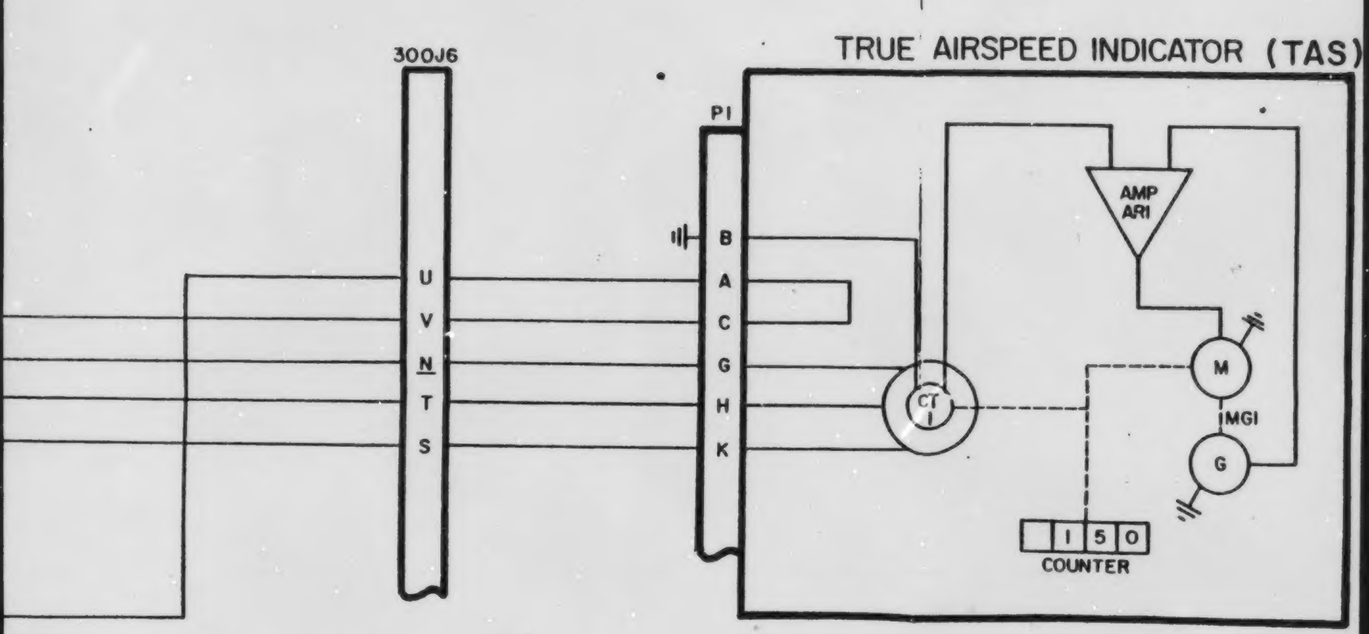
Figure 6, Section 3


TRUE AIRSPEED INDICATOR (TAS)
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COUNTER

1601

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-HO-304A
3ABR32632B-HO-404A
19 January 1977

GLOSSARY OF TERMS

This handout is designed to be used in conjunction with Programmed Text 3ABR32531-PT-304/3ABR32632B-PT-404, Central Air Data Computer System Operation. This handout contains terms and definitions applicable to the Central Air Data Computer System.

1. Airspeed Mach Indicator (AMI) - A vertical scale indicator with angle of attack, G's, mach and airspeed sections.

2. Altitude Vertical Velocity Indicator (AVVI) - A vertical scale indicator with vertical velocity (rate-of-climb), sensitive altitude, consisting of a fine and coarse tape, and gross altitude sections.

3. Indicated Airspeed (Vc) - Actual speed of the aircraft that has not been corrected for altitude or temperature.

4. Indicated angle of attack (αi) - The angular difference between the direction of airflow and an arbitrary reference line on the aircraft that has not been corrected for mach.

5. Indicated Static Pressure (Psi) - The still and undisturbed air surrounding the aircraft (uncorrected).

6. Mach (M) - The speed that the aircraft must attain to penetrate the speed of sound. Altitude is the primary factor controlling mach.

7. Maximum Safe Mach (MSM) - The mach that the aircraft can safely fly without exceeding the temperature or structural limitations of the aircraft.

8. Maximum Safe Mach Assembly (MSMA) - An electronic component of the central air data computer system designed to compute maximum safe mach.

9. Pitot Pressure (Pt) - The combination of static pressure and impact pressure. Stated as a formula this would read Qc + Ps = Pt.

10. Pressure Altitude (Hp) - The altitude of the aircraft above or below sea level.

11. Pressure Altitude Rate of Change (Hp or Hpr) - Rate of climb or dive of the aircraft in feet per minute.

12. Total Temperature (Ti) - The temperature of the air through which the aircraft is moving.

Supersedes 3ABR32531-HO-305A, 17 December 1974.
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3360 TTGTC-W - 300; TTVSR - 1
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13. True Airspeed (Vt) - Indicated airspeed that has been corrected for total temperature and pressure altitude. The mathematical formula would be Pt + Ps + Ti = Vt.

14. True Angle of Attack (αt) - The angular difference between the direction of airflow and an arbitrary reference line on the aircraft that has been corrected for mach inside the CADC.

15. True Freestream Air Temperature (Tfat) - True freestream air temperature is the corrected total temperature. This is the actual outside air temperature.

16. Vertical Acceleration (G's) - A force of +1 "G" equals the pull of gravity, a +2 "G's" is twice the pull of gravity, and so on. However, it is possible to achieve minus (-) "G's". This will occur whenever centrifugal force overcomes the pull of gravity.

17. Wing Sweep Angle (Λ) - The angle of the wing in relation to the fuselage of the aircraft. This signal is used by the central air data system for computing maximum safe mach.

1531

PROGRAMMED TEXT
3ABR32531-PT-402
3ABR32632B-PT-502

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

GYROSCOPIC FLIGHT INSTRUMENTS

30 December 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

1532

FOREWORD

This programmed text was prepared for use in courses 3ABR32531, Avionics Instrument Systems Specialist and 3ABR32632B, Integrated Avionic Systems Specialist. The text is divided into four (4) sections with each section covering a different area. You will be tested after each section to determine if you have gained the necessary understanding of the information contained in that section. The material contained herein was validated by 40 students in the subject course. At least 90% of the students achieved the objective as stated with an average completion time of 4 hours and 38 minutes.

OBJECTIVE

Without references, identify facts pertaining to the operation and/or characteristics of flight instruments, with a minimum accuracy of 70%.

INSTRUCTIONS

This programmed text presents information in small steps called frames. Each frame is followed by some form of questioning. Immediately after reading each frame, you will make the required response. Check your answer each time with the correct answer shown at the top or bottom of every other frame. Example: The answers to frame 1 are at the top or bottom of frame 3. The answers to frame 2 are at the top or bottom of frame 4, etc. If you made an incorrect response, reread the frame before going on to the next frame. Be sure that you understand the material presented in each frame before continuing. DO NOT HURRY! If you do not understand the text, or you have a question, raise your hand and your instructor will assist you.

Note: Students enrolled in the 3ABR32531 course are required to complete all sections of this text.

Students enrolled in the 3ABR32632B course are required to complete only section A.

Supersedes 3ABR32531-1-PT-203, 19 February 1974; 3ABR32531-PT-402A, 3 February 1975.
OPR: 3360 TTG
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3360 TTGTC/W - 300; TTVSA - 1

Section A

GYROSCOPIC PRINCIPLES

SPECIAL INSTRUCTIONS

This section of the programmed text is to be studied in conjunction with an audion visual aid. Select the film titled, "Gyroscopic Principles" located at the projectors in the lab.

You will be required to read a portion of this text and then view a short segment of the film. While watching the film, you will see a "STOP" sign; this means to return to the text to read the questions and make your responses. DO NOT MARK IN THIS TEXT. USE THE RESPONSE SHEET GIVEN TO YOU BY THE INSTRUCTOR.

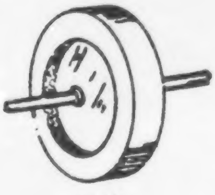
Frame 1

The high speed and maneuverability of modern aircraft demands that navigational equipment be very precise. Some of the greatest advances in flight instruments and navigation equipment have been made possible by the use of gyroscopes. The gyroscope is used in systems such as instruments and automatic flight control systems; therefore it is essential that you have a working knowledge of gyroscopes and the principles of operation.

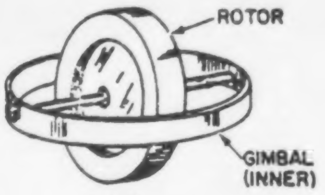
NO RESPONSE REQUIRED

Frame 2

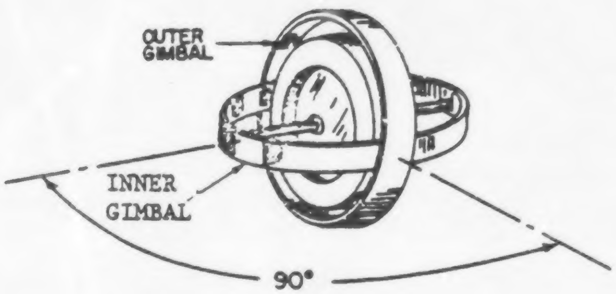
A gyroscope is a spinning mass having one or more freedoms of movement about its spin axis. The spinning mass is referred to as the rotor of the gyroscope. The rotor, as shown in A below, is constructed with most of its weight concentrated near the outer rim to increase efficiency. The rotor is mounted in a "ring" called a gimbal. See B below. This gimbal (inner) is mounted in another gimbal (outer) with bearings 90° to the rotor bearings. See C below. Adding a frame assembly, as shown in D, will support the rotor and its gimbals and give the gyroscope the freedoms of movement it requires to operate. This type of gyro is call a universally mounted gyro.



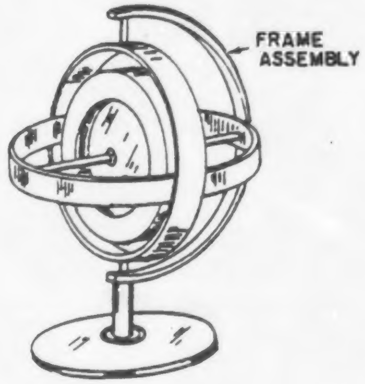
(A)



(B)



(C)



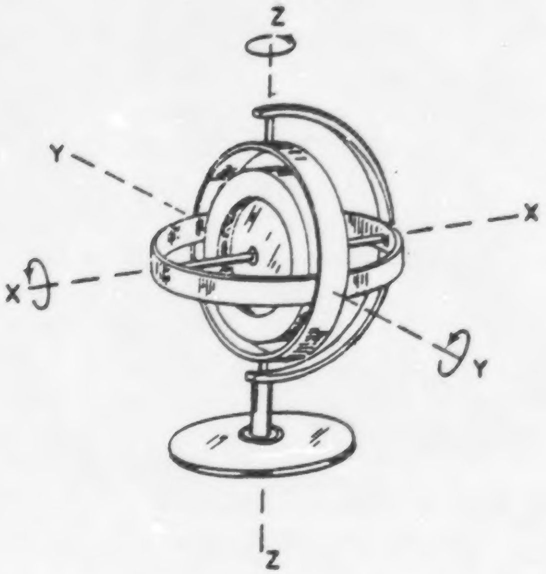
(D)

Complete the statement below by entering the correct word(s) in the space provided.

A gyroscope is a spinning mass having _________ freedoms of movement about its spin axis.

Frame 3

A universally mounted gyro has three (3) axes about which it can move. First, there is the XX axis which is the rotor's SPIN axis. Axis YY goes through the points where the inner and outer gimbals connect and allows the gyro to TILT. Axis ZZ goes through the points where the outer gimbal is attached to the frame assembly and allows the gyro to TURN.



START THE PROJECTOR. When the "STOP SIGN" appears, turn off the projector and return to this text and answer the questions at the end of the frame.

Using the illustration of the gyro and the list of components, label the parts by placing the appropriate letter in the space next to the correct number.

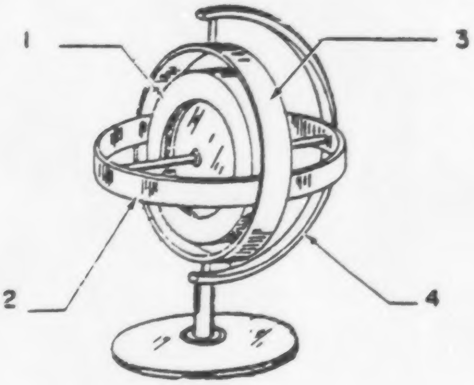
PARTS

a. Rotor

b. Frame assembly

c. Inner gimbal

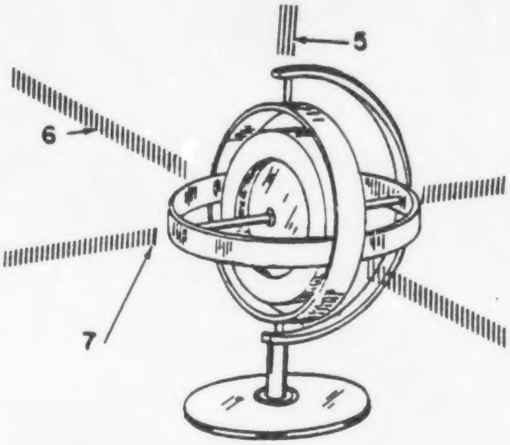
d. Outer gimbal



1536

Frame 3 (Continued)

Using the illustration of the gyro, label the SPIN axis, TURN axis, and the TILT axis by placing the correct name in the space provided.



Circle the letter next to the correct response for the statement below.

8. The two freedoms of movement about the spin axis of a universally mounted gyro are:

   a. spin and tilt.

   b. spin and turn.

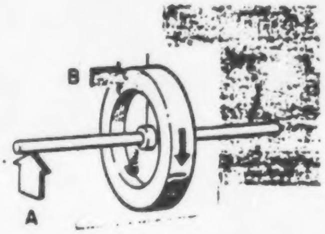
   c. turn and tilt.

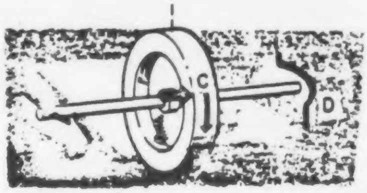
Answer to Frame 1: No response required.

Frame 4

The gyro has two basic principles of operation; precession and rigidity. Rigidity is also known as gyroscopic inertia or stability. This can be defined as the ability of a spinning mass to maintain a fixed position to a point in space. This means that once a gyro is spinning, its spin axis will always try to point in the same direction.

Precession is the resultant movement of a spinning mass when a force is applied that tries to change the spin axis, see (A) below. This means that if a force is applied to the spin axis at point (A) it is the same as applying a force to the rim of the rotor at point (B). The resultant force is felt 90 ahead of the applied force in the direction of rotation (C). This causes the gyro to turn or precess (D). Simply stated, if you try to tilt the gyro, it turns; try to turn the gyro and it tilts. Only a very small force is required to precess the gyro.





It is easier to understand rigidity and precession if you can see it. START the projector and view the section on rigidity and precession. When the "STOP SIGN" appears, turn off the projector; return to this text and circle the letter next to the best response to complete the statements below.

1. Rigidity is

   a. the ability of the gimbals to act independently of each other, allowing the gyro to tilt and turn.

   b. the ability of a spinning mass to maintain a fixed position to a point in space.

   c. the property of a gyro which causes the spin axis to be displaced in a direction 90 from an applied force in the direction of rotor rotation.

   d. the resultant movement of a spinning mass caused when a force is applied that tries to change the spin axis.

Frame 4 (Continued)

2. Precession is

   a. the resultant movement of a spinning mass caused when a force is applied that tries to change its spin axis.

   b. the property of a gyroscope that causes the gimbals to move in opposite directions when a force is applied to the rotor.

   c. the property of a gyro which causes the spin axis to be displaced in a direction 90 from an applied force in the opposite direction of rotor rotation.

   d. the ability of a gyro to hold a fixed position to any reference point.

Answer to Frame 2: one or more

Frame 5

An undesirable trait of a gyroscope is DRIFT. There are two types of drift: (1) RANDOM (MECHANICAL) DRIFT and (2) APPARENT DRIFT.

RANDOM DRIFT occurs when mechanical faults within the gyroscope apply a force to cause it to precess. The two major causes of random drift in a gyroscope are bearing friction and rotor unbalance. The bearings used to connect the rotor and gimbals are practically free of friction. These bearings are as near to being friction free as modern industry can make them but they are not perfect. As the gyro ages, the bearings also wear which produces more friction. This friction will have the same effect as applying a force to the rotor. This force causes the gyroscope to precess or drift.

If the rotor is not properly balanced, then this condition will also cause drift. If one part of the rotor is heavier than the rest, a state of unbalance will exist which will have the same effect as applying a force to the rotor, resulting in gyro precession.

Circle the number(s) of the true statements below.

1. Precession can be caused by mechanical faults within the gyroscope and is known as random (mechanical) drift.
2. The two major causes of random drift are bearing friction and rotor unbalance.
3. Mechanical drift and rotor unbalance are not related.

Answers to Frame 3: 1. a 2. c 3. d 4. b 5. turn

6. tilt 7. spin 8. [✓ c]

1540

Answers to Frame 4: 1. b 2. a

Frame 6

The second type of drift is referred to as "apparent drift." As opposed to random drift, the rotor does not precess, but only appears to as the position of the frame changes around it. Apparent drift is caused by the rotation of the earth and the rigidity of the gyroscope. Rigidity prevents the spin axis of the gyro from rotating along with the earth. To a person standing on the earth, the rotor of the gyro only "appears" to drift.

NOW CHANGE THE FILM CARTRIDGE TO THE SECOND ONE (AVA 521 B). Pay special attention to the pictorial explanation of apparent drift.

START THE PROJECTOR

After viewing the film, circle the letter of the correct responses below.

1. Apparent drift is caused by
    a. applying a force to the inner gimbal.
    b. earth rotation and drift.
    c. earth rotation and precession.
    d. earth rotation and rigidity.
2. Because of apparent drift, the gyro spin axis as seen from space
    a. maintains a fixed position.
    b. appears to turn.
    c. appears to tilt.

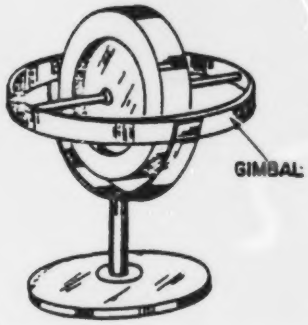
Answers to Frame 5: 1, 2

Frame 7

There are two types of gyroscope mountings; universal and semiuniversal. The universally mounted gyroscope has two gimbals and two freedoms of movement about the spin axis; tilt and turn. The semiuniversally mounted gyroscope has only one gimbal (see below) and one freedom of movement about the spin axis. This freedom of movement is tilt.

View the film. When the "stop sign" appears, return to the text and complete the questions at the end of this frame.

START THE PROJECTOR



SEMIUNIVERSALLY MOUNTED GYRO

Complete the statements below by circling the correct letter.

1. The universally mounted gyroscope has
    a. three gimbals and one freedom of movement about the spin axis.
    b. two gimbals and two freedoms of movement about the spin axis.
    c. one gimbal and two freedoms of movement about the spin axis.
    d. one gimbal and one freedom of movement about the spin axis.

2. The semiuniversally mounted gyroscope has
    a. two gimbals and two freedoms of movement about the spin axis.
    b. one gimbal and one freedom of movement about the spin axis.
    c. two gimbals and one freedom of movement about the spin axis.
    d. three gimbals and three freedoms of movement about the spin axis.

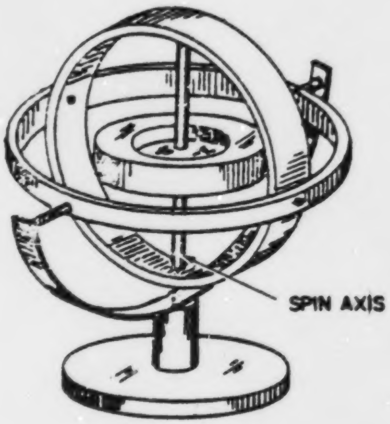
Answers to Frame 6: 1. d, 2. a

Frame 8

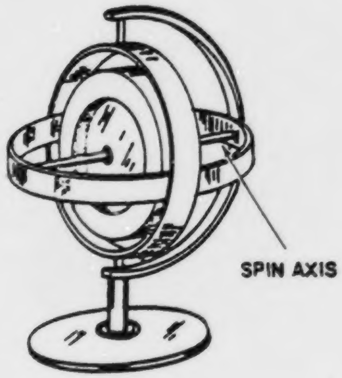
There are two basic applications of universally mounted gyroscopes. The main difference is the position of the spin axis (see below). A universally mounted gyro is used as a vertical gyro. The vertical gyro is used in the aircraft as a reference for pitch and roll attitude changes. Its spin axis is perpendicular to the earth. The gyro's frame assembly is attached directly to the aircraft. The aircraft can move in pitch and roll without changing the gyro's spin axis. Signal pickoff's are used to sense the amount of attitude change of the aircraft.

The other application of the universally mounted gyro is the directional gyro (D.G.). This type of gyro has a horizontal spin axis. It is used in compass systems as a reference for obtaining heading information.

Both the vertical and directional gyros are known as displacement gyros, because they are used to measure the amount of displacement from their reference. Leveling devices must be used to keep the spin axis of the gyro either vertical or horizontal to the earth's surface.



VERTICAL GYRO



DIRECTIONAL GYRO

Watch the section of the film on how gyros are used in aircraft. Then return to the programmed text and answer the following questions.

START THE PROJECTOR

Complete the following statements by circling the correct letter.

1. A vertical gyro in an aircraft is used as a reference for

   a. heading changes.

   b. making a 180° turn.

   c. attitude changes.

2. A horizontal or directional gyro in an aircraft is used as a reference for

   a. heading changes.

   b. pitch and roll.

   c. attitude changes.

3. In the film, the aircraft going into a climb and then a dive was using a

   a. directional gyro.

   b. D.G.

   c. vertical gyro.

   d. horizontal gyro.

4. In the film, what type of universally mounted gyro was used in the aircraft making a 180° turn?

   a. Directional gyro with a horizontal spin axis.

   b. Rate gyro.

   c. Vertical gyro.

5. Vertical and directional gyros are known as

   a. semiuniversally mounted gyros.

   b. displacement gyros.

   c. rate gyros.

Answers to Frame 7: 1. b, 2. b

Frame 9

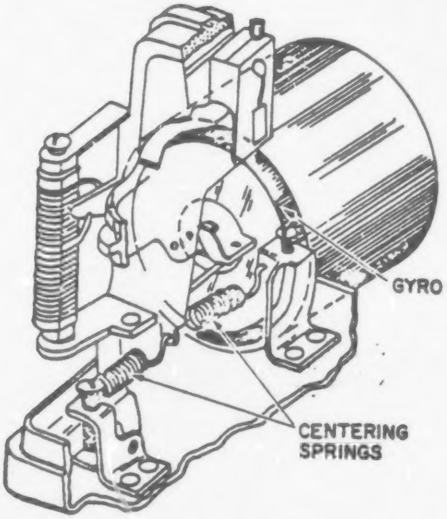
The gyros mentioned up to now all use the property of rigidity, enabling the gyro to be used as a reference for displacement.

The semiuniversally mounted gyro is used as a rate gyro (see below). The rate gyro senses rate of movement instead of displacement. This gyro uses the property of precession for its operation.

Centering springs (see below) are used to keep the gyro's spin axis aligned with the gyro frame assembly. As the aircraft turns, the frame assembly also turns. The spinning rotor resists the change and causes the gyro to precess. As the precessing force becomes large enough, the spring tension is overcome. The faster the aircraf turns, the further the gyro will precess. A signal pickoff device is used to develop signals proportional to the rate of the turn.

View the film. When "the end" appears, return to the text and complete the PT.

START THE PROJECTOR



Circle the correct statement(s) below.

1. The rate gyro has two freedoms of movement about the spin axis.

2. The rate gyro uses a semiuniversal mounting.

3. The rate gyro uses springs to keep the spin axis aligned with the frame assembly.

1545

Answers to Frame 8: 1. c, 2. a, 3. c, 4. a, 5. b

Frame 10

Review what you have learned about gyroscopic principles. If any areas seem unclear, return to the text and the film. If you feel confident in your knowledge, answer the following questions as a review.

Complete the statement below by circling the correct letter.

1. A gyroscope is defined as a

   a. spinning mass mounted in a frame assembly.

   b. balanced spinning mass or wheel.

   c. spinning mass having one or more freedoms of movement about its spin axis.

   d. spinning mass or wheel mounted in the outer gimbal.

Using the illustration of the gyro and a list of components, label the gyro parts. Place the letter of the part near the number.

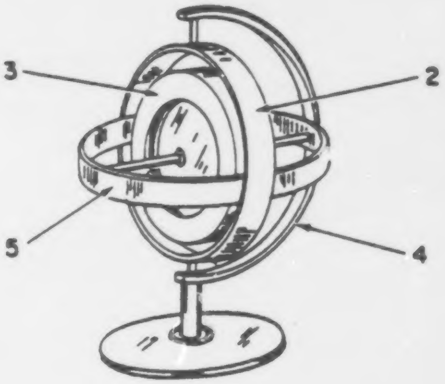
PARTS

a. Rotor.

b. Frame assembly.

c. Inner gimbal.

d. Outer gimbal.



1546

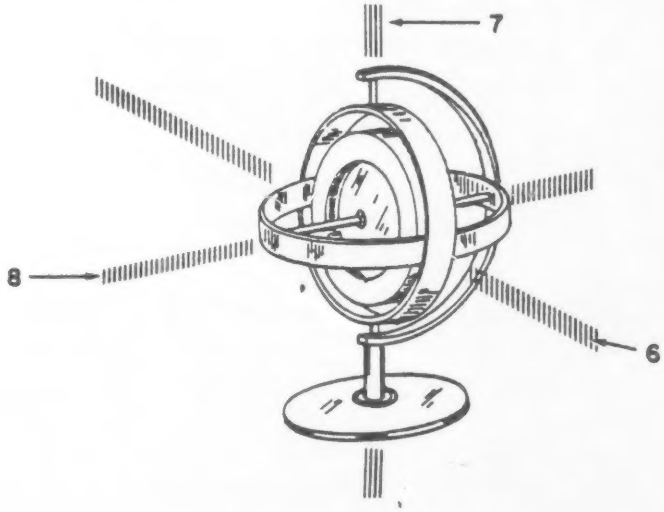
Frame 10 (Cont'd)

Using the illustration of the gyro, label the SPIN axis, TURN axis, and the TILT axis. Place the correct letter near the number.

a. Spin

b. Turn

c. Tilt



9. **Rigidity is**

a. the resultant movement of a spinning mass caused when a force is applied that tries to change the spin axis.

b. the property of a gyro which causes the gyro to turn when you try to tilt it.

c. the ability of the gimbals to act independently of each other allowing the gyro to turn or tilt.

d. the ability of a spinning mass to maintain a fixed position to a point in space.

1547

10. Precession is

a. the resultant movement of a spinning mass caused when a force is applied that tries to change the spin axis.

b. The property of a gyro which causes the gimbals to move in opposite directions anytime a force is applied to the rotor.

c. the property of a gyro which causes the spin axis to be displaced in a direction 90° from an applied force in the opposite direction of rotation.

d. the ability of a gyroscope to hold a fixed position to any reference point.

11. Apparent drift is caused by

a. the earth's rotation and rigidity.

b. applying a force to the inner gimbal.

c. the earth's rotation and bearing friction.

d. the earth's rotation, and gyro precession.

12. Mechanical drift is caused by

a. the earth's rotation.

b. the earth's rotation and bearing friction.

c. the earth's rotation and rigidity.

d. bearing friction or rotor unbalance.

13. Random (mechanical) drift will appear in

a. semiuniversal gyros.

b. directional gyros.

c. vertical gyros.

d. all types of gyros.

14. Because of apparent drift, the gyro spin axis as seen from space

a. maintains a fixed position.

b. appears to turn along with the earth.

c. appears to tilt along with the earth.

1620

1548.

Frame 10 (Cont'd)

15. The semiuniversally mounted gyroscope has

a. two gimbals and two freedoms of movement about the spin axis.

b. one gimbal and one freedom of movement about the spin axis.

c. two gimbals and one freedom of movement about the spin axis.

d. three gimbals and three freedoms of movement about the spin axis.

16. The universally mounted gyroscope has

a. two gimbals and two freedoms of movement about the spin axis.

b. one gimbal and one freedom of movement about the spin axis.

c. two gimbals and one freedom of movement about the spin axis.

d. three gimbals and two freedoms of movement about the spin axis.

Mark the following statements (T) true or (F) false in the spaces provided.

____17. Vertical and directional gyroscopes are known as displacement gyros.

____18. A universally mounted gyroscope with a horizontal spin axis is used as a reference for obtaining heading information.

____19. Semiuniversally mounted gyros are used to make rate gyros.

____20. The universally mounted gyroscope with a vertical spin axis is used as a reference for attitude changes.

1621

Answers to Frame 9: 2, 3

Answers to Frame 10: 1. c, 2. d, 3. a, 4. b, 5. c, 6. c,
7. b, 8. a, 9. d, 10. a, 11. a, 12. d,
13. d, 14. a, 15. b, 16. a, 17. T, 18. T,
19. T, 20. T

If any questions were missed in frame 10, return to the frames that cover the material that was missed and review it. After you have an understanding of the material presented in the Section A, ask your instructor for the appraisal.

NOTE!

3ABR32632B STUDENTS STOP HERE.

3ABR32531 STUDENTS CONTINUE.

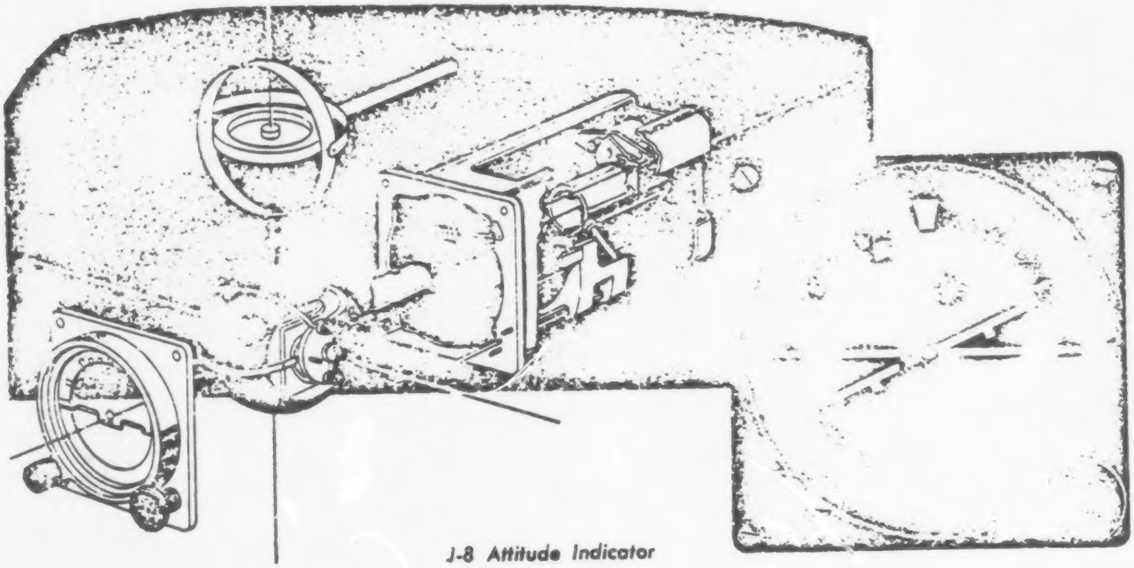
1550

Section B

J-8 ATTITUDE INDICATOR

Frame 1

One of the more important instruments employing gyroscopic principles is the attitudy indicator. The instrument we will study is the type J-8 Attitude Indicator. It is one of the few gyro instruments that is not remotely controlled. The illustration below shows an exploded view and the face (front) of the J-8 Attitude Indicator. This indicator provides an indication of the aircraft's attitude (position) in relation to the earth's horizon. In other words, the pilot can determine, from the indications the J-8 provides, whether the aircraft is in a dive, climb, level flight, or banking right or left in relation to the earth's horizon.



J-8 Attitude Indicator

Circle the letter that identifies the correct answer.

The above indicator is used to provide indications of the aircraft's

a. degree of bank only.

b. rate of turn.

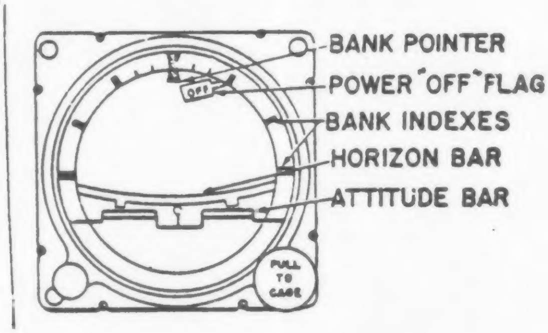
c. pitch only.

d. attitude.

1623

Frame 2

Notice in the picture below, that some of the components are labeled. For easier understanding, let's take a few items at a time. The first one we will cover is the miniature aircraft or attitude bar, which is connected to the case. Another is the horizon bar, which is connected to the outer gimbal ring of the gyro and represents the earth's horizon.



The angle of dive or climb is indicated by the number of bar width deflections between the horizon bar and the attitude bar (miniature aircraft). One horizon bar width is equal to 2 degrees pitch. If the attitude bar is above the horizon bar, the aircraft is in a climb.

Circle the letter that identifies the correct answer.

1. The attitude bar is used to represent the

   a. horizon.

   b. aircraft.

   c. degree of bank.

   d. degree of pitch.

2. The horizon bar is used to represent the

   a. horizon.

   b. aircraft.

   c. degree of bank.

   d. degree of pitch.

3. The horizon bar is 3 bar widths below the attitude bar, this indicates the aircraft is

   a. diving by 3°.

   b. climbing by 3°.

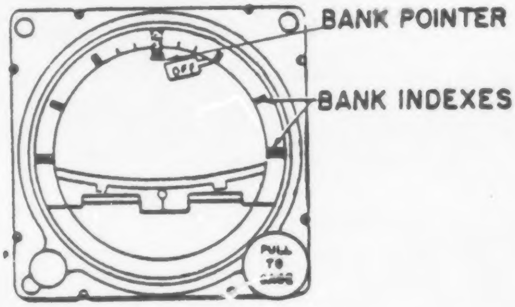
c. c. climbing by 6°.

   d. diving by 6°.

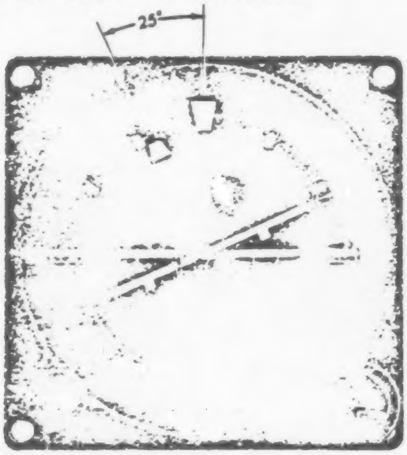
Answer to Frame 1: 1. d

Frame 3

The attitude of the aircraft about the roll axis is indicated by the position of the bank pointer in relation to the bank scale. (Refer to illustration below.)



The bank scale is marked with indices at 0°, 10°, 20°, 30°, 60°, and 90° left and right bank. If the bank pointer is deflected to the right, the aircraft is in a left bank attitude. The illustration below shows an attitude of 25° right bank. Notice that the "right wing" of the miniature aircraft is below the horizon.



Circle the letter that identifies the correct answer.

1. The bank pointer is deflected to the left, the horizon bar is deflected above the attitude bar, the aircraft is banking

   a. right and diving.
   b. left and diving.
   c. right and climbing.
   d. left and climbing.

2. The bank pointer is deflected left to the first increment, the degree of bank is

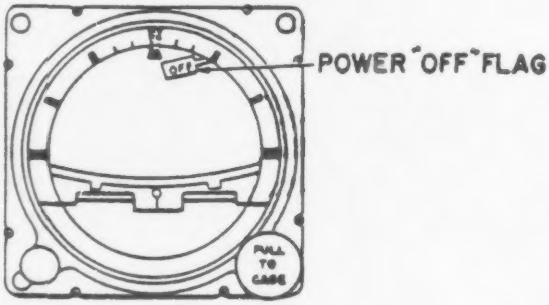
   a. 90°.
   b. 30°.
   c. 20°.
   d. 10°.

Answers to Frame 2: 1. b 2. a 3. c

Frame 4

The power off flag is used to warn the pilot of AC power failure or low power to the indicator. The power off flag is operated by a 2-phase low inertia motor and a hairspring. Whenever power is turned on, the motor is energized and the flag is pulled out of sight. However, when power is shut off, the hairspring pulls the flag back into view. The above is for normal operating conditions.

If power is low to the indicator, the motor does not develop enough torque to overcome the hairspring tension, so the flag remains in sight.



Circle the letter that indicates the correct answer.

1. The power off flag is used to warn the pilot of

   a. DC power failure on the aircraft.

   b. DC power failure to the indicator.

   c. AC power failury on the aircraft.

   d. AC power failure to the indicator.

2. The power off flag is operated by a/an

   a. hairspring only.

   b. DC motor.

   c. AC motor and hairspring.

   d. DC motor and hairspring.

1554

Answers to Frame 3: 1. a 2. d

Frame 5

The pitch attitude of the aircraft is indicated within a range of 27 degrees in climb or dive by the displacement of the horizon bar with respect to the adjustable attitude bar. When the aircraft exceeds 27° in pitch, the horizon bar is held in the extreme position and the sphere becomes the new reference.

Circle the letter that indicates the correct answer.

1. The horizon bar provides pitch reference for attitudes

   a. above 27° climb or dive.

   b. up to 27° climb only.

   c. up to 27° climb or dive.

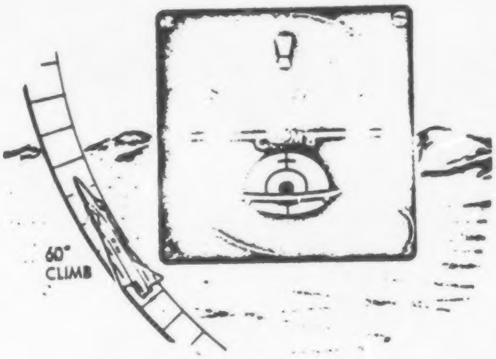
   d. below 27° dive only.

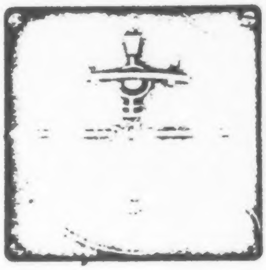
1627

Answers to Frame 4: 1. d 2. c

Frame 6

The sphere is marked by the words "Climb" and "Dive," and each is followed by a "Bullseye." (Refer to the illustration.) The words climb or dive when directly under the attitude bar represent approximately 60° of pitch. The bullseye is graduated at 70°, 80°, and 90° of pitch.





Circle the letter that indicates the correct answer.

1. The word "Dive" appears under the attitude bar, the instrument is indicating a

a. 60° climb.

b. 60° left bank.

c. 27° dive.

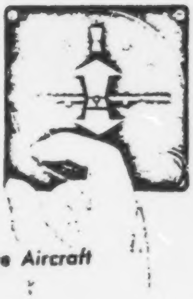
d. 60° dive.

1556

Answers to Frame 5: c

Frame 7

There are two knobs located on the front of the instrument. The knob on the lower left is called the attitude trim knob. This knob is used by the pilot to manually correct for level flight errors (trim errors), on the J-8, caused by changes in cruising speeds and in load conditions.



Adjusting the Miniature Aircraft

Circle the letter that indicates the correct answer.

1. Trim errors on the instrument are corrected for by the

    a. pull to cage knob.

    b. pilot viewing the indicator at different angles.

    c. attitude trim knob.

    d. caging clip.

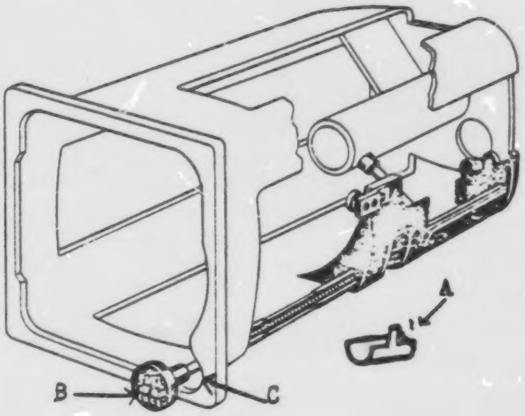
1629

1557

Answer to Frame 6: d

Frame 8

The knob on the lower right side of the instrument is called a caging knob. This knob, when pulled out, operates a caging mechanism which locks the inner and outer (roll and pitch) gimbals. The purpose of the caging mechanism is to provide a means for quickly erecting the gyro. When caging the instrument, pull the caging knob out smoothly. A small clip (A), called a caging clip (refer to illustration), is installed between the caging knob (B) and instrument's bezel (C) to cage the gyro during shipping, handling, and storage.



Caging Mechanism

Circle the letters that identify true statements.

a. The caging knob locks the inner and outer gimbal rings.

b. The caging knob provides a means for erecting the gyro very slowly.

c. When the caging knob is pulled out the attitude bar and bullseye will be aligned.

d. When the caging knob is pulled out, a caged flag appears.

e. The caging clip is installed during shipping, handling, or storage.

f. The caging knob provides a means for quickly erecting the gyro.

1558

Answer to Frame 7: c

Frame 9

The indicator permits 360° of rotation about the roll and pitch axis without causing the gyro to tumble. As the aircraft approaches a vertical attitude (90°), as in a loop, the sphere begins to rotate 180° (counterclockwise when in a climb, and clockwise in a dive) to show the inverted attitude of the aircraft. The rotation of the sphere is called controlled precession and should not be confused with gyro tumbling. (Study the indications on the next page, frame 10.)

Circle the letter that indicates the correct answer.

1. The indicator can show, without controlled precession,

    a. 360° pitch, 360° roll.

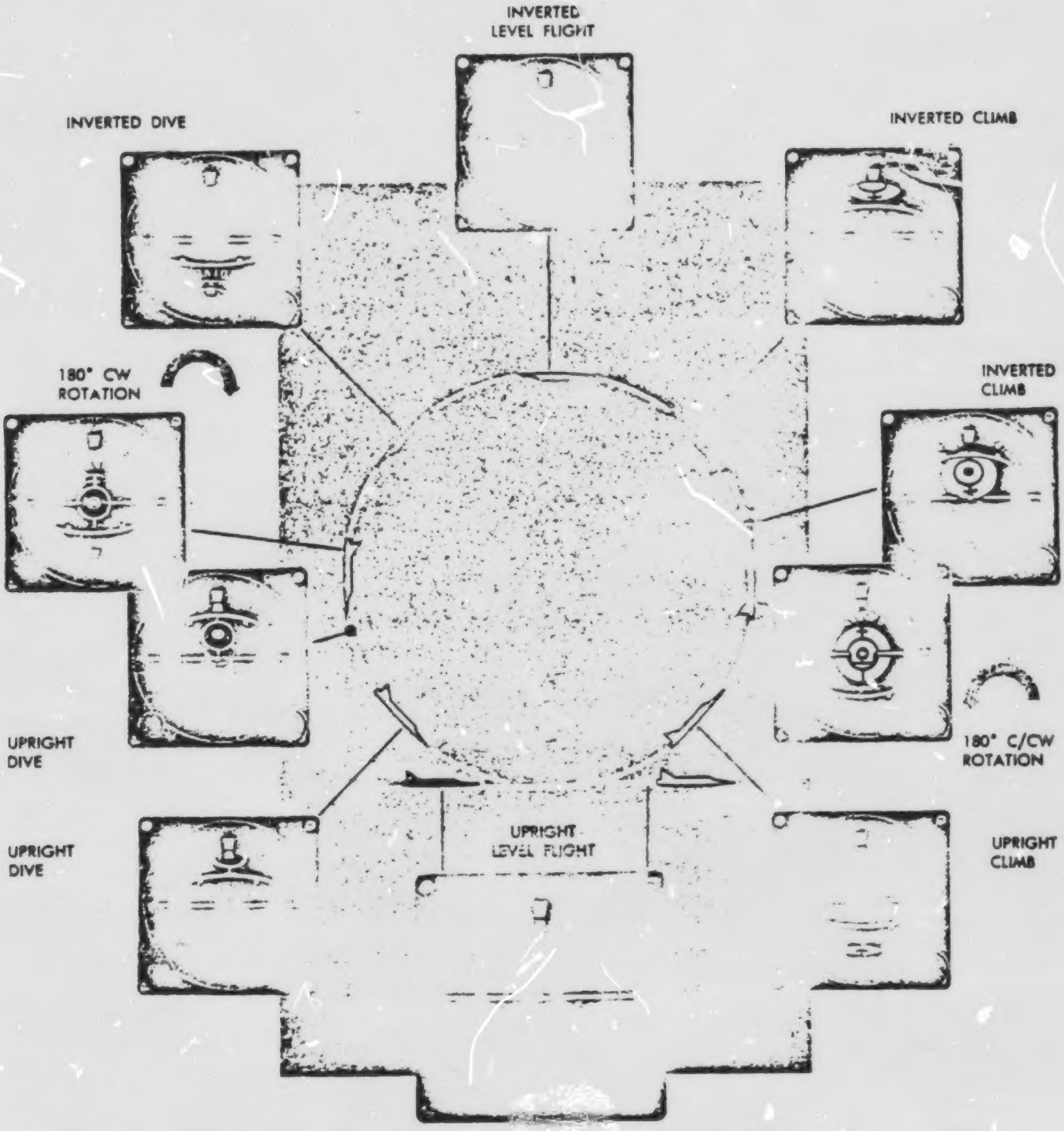
    b. 360° pitch, 90° roll.

    c. 360° roll, 90° pitch.

    d. 180° roll, 90° pitch.

Answers to Frame 8: a e f

Frame 10


INVERTED LEVEL FLIGHT
INVERTED DIVE
INVERTED CLIMB
180° CW ROTATION
INVERTED CLIMB
UPRIGHT DIVE
180° C/CW ROTATION
UPRIGHT DIVE
UPRIGHT LEVEL FLIGHT
UPRIGHT CLIMB

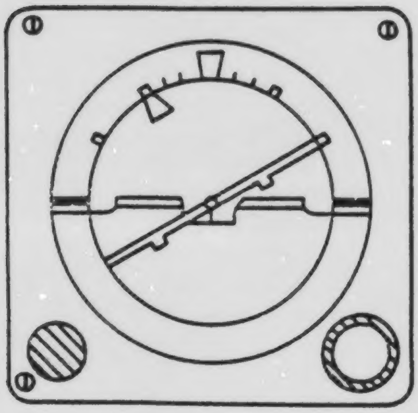
J-8 Attitude Indications During a Loop Maneuver

Answer to Frame 9: c

Frame 11

In the blank spaces provided, indicate the attitude of the aircraft according to the indication in both pitch and bank in degrees.

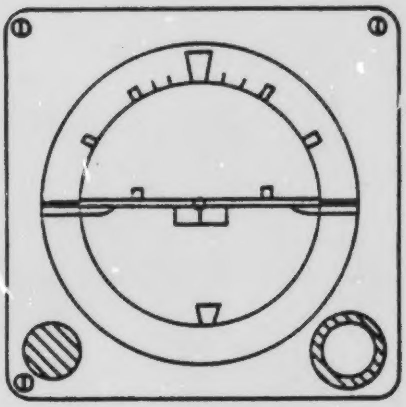
1.



____

____

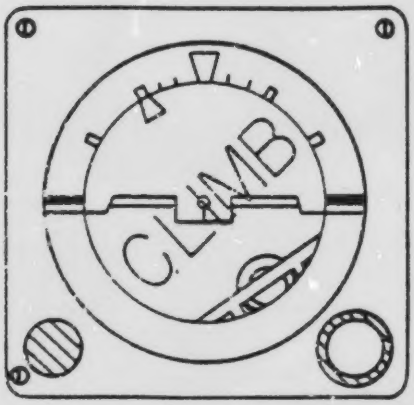
2.



____

____

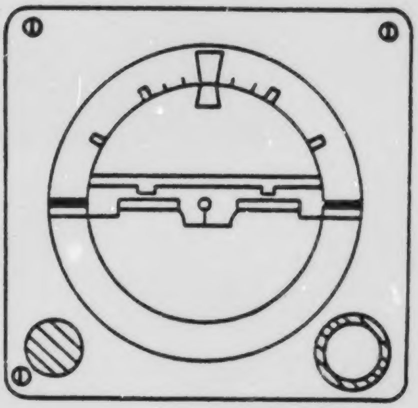
3.



____

____

4.



____

____

/////////////////

1. 30 degrees right bank.

2. Level inverted flight.

3. 30 degrees right bank
60 degrees climb.

4. Dive 6 degrees

Answers to Frame 10: No response required.

Frame 12

The gyro is universally mounted and operates on the principles of rigidity. The spin axis of the gyro is vertical since all attitude gyros use a vertical spin axis. The power requirement is 115 volts, 400 Hertz 3-phase AC. The speed of the gyro is approximately 21,000 rpm.

Complete the following statements.

1. The gyro is ____________ mounted and operates on the principles of ______________________________.

2. The gyro's spin axis is ________________________.

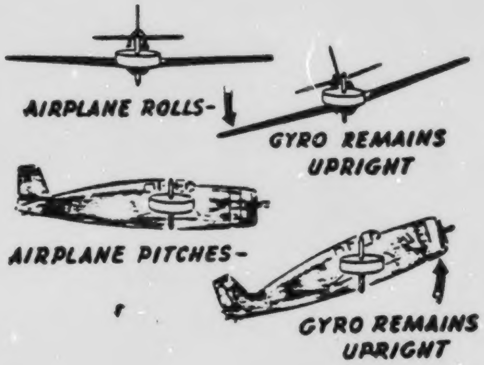
1562

Answers to Frame 11:

1. 30 degrees right bank.
2. Level inverted flight.
3. 30 degrees right bank
60 degrees climb.
4. Dive 6 degrees.

Frame 13

Due to the gyro's rigidity and its universal mounting, the rotor remains fixed in this position regardless of the aircraft's movement. The horizon bar and bank pointer are linked to the outer gimbal ring. The attitude bar and scale are attached to the case. Movement of the case around the gyro produces the indications.


AIRPLANE ROLLS-
GYRO REMAINS UPRIGHT
AIRPLANE PITCHES-
GYRO REMAINS UPRIGHT

Mark the following statements true (T) or false (F).

1. _____ The gyro moves when the aircraft banks.

2. _____ The gyro remains erect when the aircraft banks.

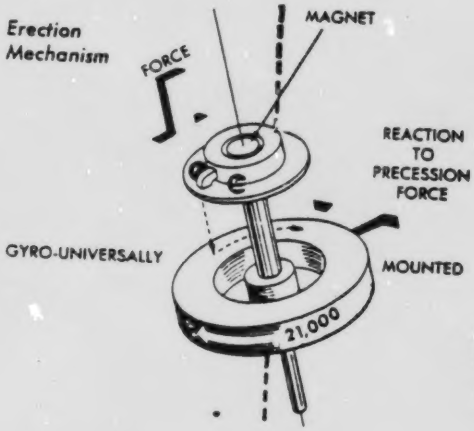
3. _____ The case revolves around the gyro.

1635

Answers to Frame 12: 1. universally - rigidity 2. vertical

Frame 14

The erection mechanism, located at the top of the gyro assembly, is used to keep the gyro erect on its spin axis. The erection mechanism operates on the gyroscopic principle of precession. The illustration below shows the gyro tilted from the vertical position. The two steel balls will fall to the low side when the gyro is not erect (vertical) and cause a force to be applied to precess the gyro back to the vertical position.


Erection Mechanism
FORCE
MAGNET
REACTION TO PRECESSION FORCE
GYRO-UNIVERSALLY
MOUNTED
21,000

Circle the letter that identifies the correct answer.

1. The erection mechanism operates on the principle of
   a. rigidity.
   b. inertia.
   c. apparent precession.
   d. precession.

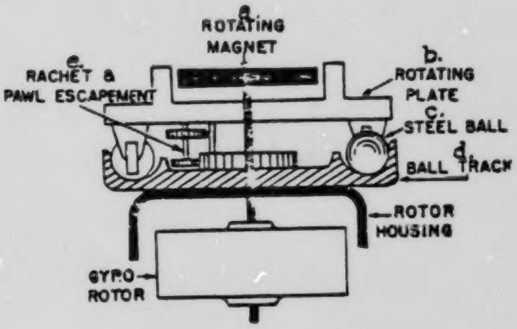
2. The purpose of the erection mechanism is to
   a. keep the gyro spinning.
   b. apply a force to unbalance the gyro.
   c. keep the gyro erect on its vertical spin axis.
   d. keep the gyro erect on its horizontal spin axis.

1564

Answers to Frame 13: 1. F 2. T 3. T

Frame 15

The components of the erection mechanism are as follows (refer to illustration): A rotating magnet (a) is connected to the gyro's shaft, and sets up a rotating magnetic field. A rotating plate (b) (magnetic drag assembly) is made of a nonmagnetic material, and is used to push the steel balls (c) around the ball track (d). It also incorporates a ratchet and pawl escapement (e) that controls the speed of the rotating plate at approximately 49 to 52 rpm.


a.
ROTATING MAGNET
e.
RACHET & PAWL ESCAPEMENT
b.
ROTATING PLATE
c.
STEEL BALL
d.
BALL TRACK
ROTOR HOUSING
GYRO ROTOR

Match the components from table 1 to their purpose in table 2.

TABLE 1.	TABLE 2
1. ___ Ratchet and pawl assembly.	a. Sets up a rotating magnetic field.
2. ___ Rotating magnet.	b. Pushes the balls around.
3. ___ Steel balls.	c. Controls the speed of the plate.
4. ___ Rotating plate.	d. Causes precession.
5. ___ Rotor speed.	e. 49 to 52 rpm.
6. ___ Rotating plate speed.	f. Approximately 21,000 rpm.

Answers to Frame 14: 1. d 2. c

Frame 16

Whenever you install a new instrument, you will find the caging clip installed on the pull to cage knob. Be sure to remove this to insure proper operation of the instrument. After installing the instrument, you should check it for proper operation.

Circle the letter that identifies the correct answer.

1. To insure proper indications of the instrument you should always be sure that the

a. caging knob is locked.

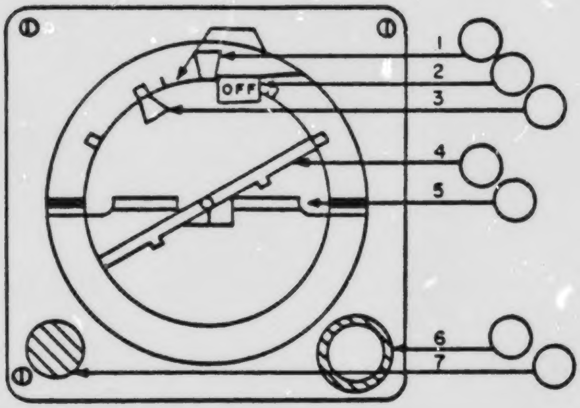
b. cage clip is removed.

c. attitude bar is caged.

d. 115V 60 Hertz 1Ø power is applied.

Answers to Frame 15: 1. c 2. a 3. d 4. b 5. f 6. e

Frame 17



I. Using the illustration, insert the letter designations of the component parts listed in the appropriate circles.

a. Bank Pointer.
b. Horizon Bar.
c. Attitude Bar.
d. Power Off Flag.
e. Attitude Trim Knob.
f. Caging Knob.
g. Bank Index.

II. Mark each statement True (T) or False (F).

1. ___ The attitude bar represents the aircraft.
2. ___ The horizon bar is adjusted up and down for trim error.
3. ___ The caging knob provides for quick erection of the gyro when pulled out.
4. ___ The gyro operates on the principle of precession.
5. ___ The speed of the gyro is approximately 50 rpm.
6. ___ The erection system operates on the principle of precession.
7. ___ The erection system speed is approximately 21,000 rpm.
8. ___ The attitude bar is linked to the gyro's outer gimbal ring.
9. ___ The power requirement for the power off flag is 28V DC.
10. ___ The roll axis is indicated by comparing the horizon bar to the attitude bar.
11. ___ If the bank pointer is deflected to the right, the aircraft is turning right.
12. ___ If the horizon bar is above the attitude bar, the aircraft is diving.

Answers to Frame 16: 1. b

Answers to Frame 17:

I. 1. g 2. d 3. a 4. b 5. c 6. f 7. e

II. 1. T 2. F 3. T 4. F 5. F 6. T 7. F 8. F 9. F

10. F 11. F 12. T

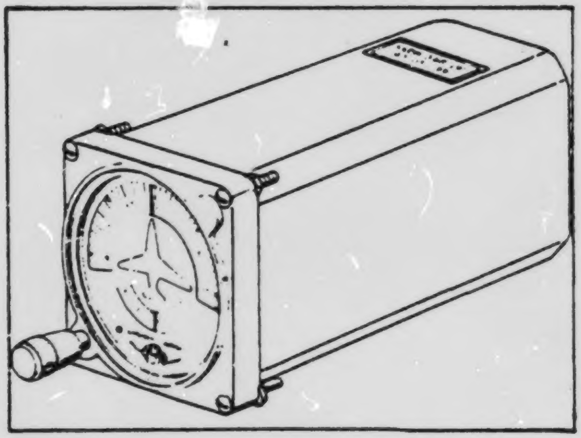
If you have missed any questions in frame 17, return to the appropriate frame to insure a complete knowledge of the materials presented in Section B. After you have reviewed this section ask the instructor for the appraisal for Section B.

Section C

DIRECTIONAL GYRO INDICATOR

Frame 18

The Directional Gyro Indicator (below) is an auxiliary instrument which provides a visual indication of aircraft heading. This heading information can be used for navigational purposes. This indicator is also used in event of failure of the main aircraft compass system. Under normal flight conditions, the aircraft compass system uses the earth's magnetic field as directional reference. The Directional Gyro Indicator does not use the earth's magnetic field as a reference; therefore, it can be used in polar regions, or where the earth's magnetic field is not reliable.



Directional Gyroscopic Indicator,

Operating voltage gyroscope	26 ± 3 volts, 400 ± 40 cps, three phase.
Operating voltage clutch	18 ± 2 volts dc
Total length	9-1/16 inches max
Width	3-5/16 inches max
Height	3-5/16 inches max
Weight	4.3 pounds max

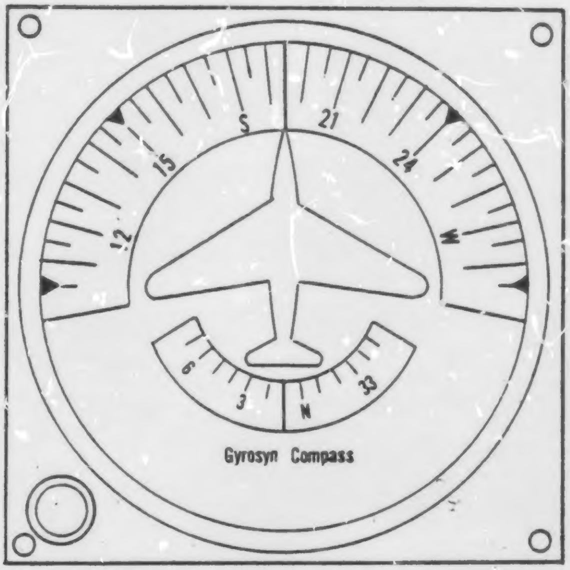
Place a checkmark (✓) in front of the true statements below.

_____1. The function of the Directional Gyro Indicator is to provide a visual indication of aircraft heading.

_____2. The Directional Gyro Indicator cannot be used as an auxiliary instrument.

_____3. The Directional Gyro Indicator does not use the earth's magnetic field as a directional reference.

The heading display is a calibrated dial that rotates relative to a fixed index (top lubber line). The dial contains increments every five degrees. Numbers are provided every thirty degrees. The dial also has the letters "N, S, E, and W" at the cardinal headings. The dial is read beneath a lubber line at the top of the indicator. The lubber line is in line with the nose of a miniature aircraft symbol. Two other indices are provided as reference marks used in making 45° and 90° turns. The dial of a Directional Gyro is illustrated below.



Complete the statements below by underlining the correct answer(s).

1. The dial has reference increments every (1, 5, 10, 15) degrees.

2. The dial has numbers every (5, 10, 15, 30) degrees.

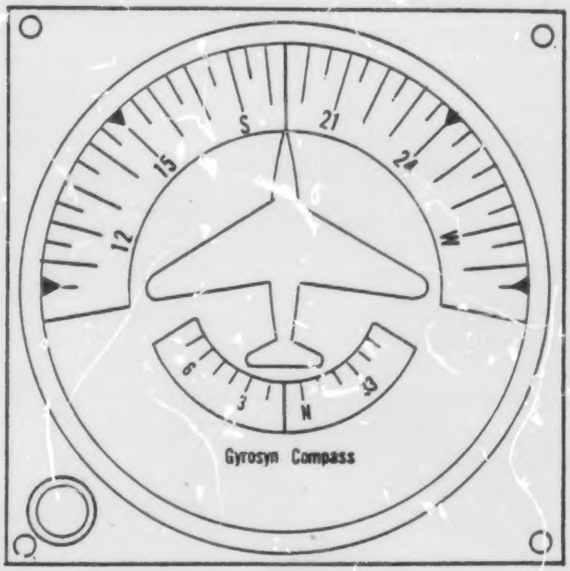
3. (Numbers, letters) are provided at the four cardinal headings.

4. Indices are provided for making (15, 45, 60, 90) degree turns.

Answers to Frame 18: ✓ 1. ___ 2. ✓ 3.

Frame 20

This indicator does not use outside signals, such as the earth's magnetic field, as a directional reference. Before accurate heading indications can be read from the indicator, the correct magnetic heading must be manually set on the dial. Setting the dial to the correct heading is accomplished by using the spring loaded push-to-set knob on the front of the indicator.



Complete the statements below by underlining the correct answer.

1. The function of the knob on the front of the indicator is to position the (indicator gyro, indicator dial).

2. The indicator uses (no, one, three) outside heading references(s).

1571

Answers to Frame 19: 1. 5 2. 30 3. letters 4. 45, 90

Frame 21

Normally the position of the indicator dial is controlled by a gyro inside the indicator case. Because the gyro drifts due to bearing friction and the earth's rotation, the pilot must constantly monitor and reset the dial. Resetting the dial to the correct aircraft heading is done to obtain accuracy in making aircraft turns.

Complete the statements below by underlining the correct answer(s) in the parentheses.

1. The position of the indicator dial is controlled by a (compass, gyro).

2. The dial must be manually set to the (degree of aircraft turn, aircraft heading).

1644

1572

Answers to Frame 20: 1. indicator dial 2. no

Frame 22

When the dial is set to the correct heading, a change in aircraft heading causes the dial to turn the same amount that the aircraft has turned. The new aircraft directional heading can then be read at the top lubber line. Because this indicator uses a gyro as a stable reference, it is more accurate in turns than the magnetic compass. The aircraft magnetic compass is not accurate because its magnets and dial are mounted in fluid for damping purposes. This causes the dial to lag the actual heading during turns.

Complete the statements below by underlining the correct answer(s).

1. Aircraft directional heading is read at the (top, bottom) lubber line.

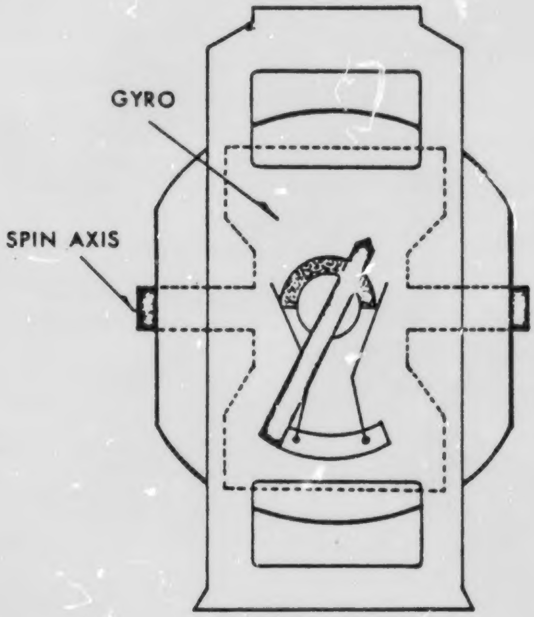
2. A (magnet, gyro) inside the indicator case provides a stable reference during aircraft turns.

3. The (Directional Gyro Indicator, Magnetic Compass) is more accurate during aircraft turns.

Answers to Frame 21: 1. gyro 2. aircraft heading

Frame 23

The Directional Gyro inside the indicator case has a horizontal spin axis. The spin axis is maintained parallel to the earth by means of a leveling circuit. This circuit senses when the gyro spin axis is not level. Through the gyroscopic principle of precession, the gyro is precessed back to level.



Complete the following statements below by underlining the correct answer(s).

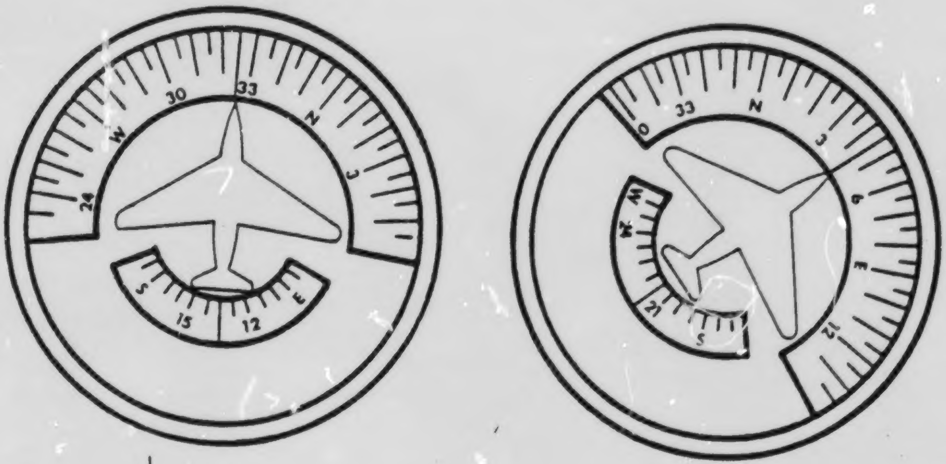
1. The indicator gyro has a (vertical, horizontal) spin axis.

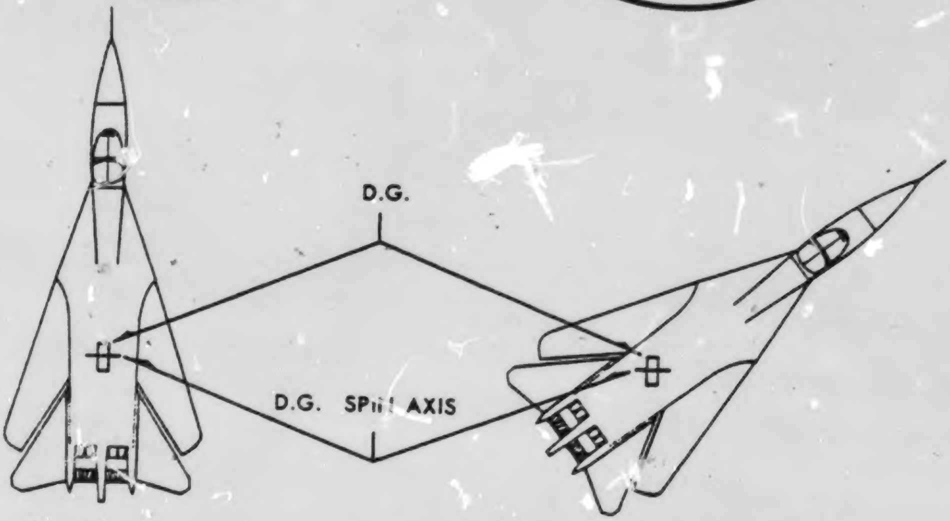
2. (Rigidity, Precession) is the gyroscopic principle which is used to keep the gyro level.

Answers to Frame 22: 1. top 2. gyro 3. Directional Gyro Indicator

Frame 24

With the gyro held level by the leveling circuit, the gyroscopic principle of ridigity holds the gyro in a fixed position. As the aircraft turns, the indicator case turns with it, while the gyro holds its fixed position. This causes the dial to turn the same amount that the aircraft and indicator has turned about the gyro. The new aircraft heading is then read at the top lubber line.





Complete the following statements below by underlining the correct answer(s).

1. The gyroscopic principle of (rigidity, precession) enables the gyro to hold a fixed position during turns.

2. The indicator (dial, gyro) turns the same amount as aircraft turns.

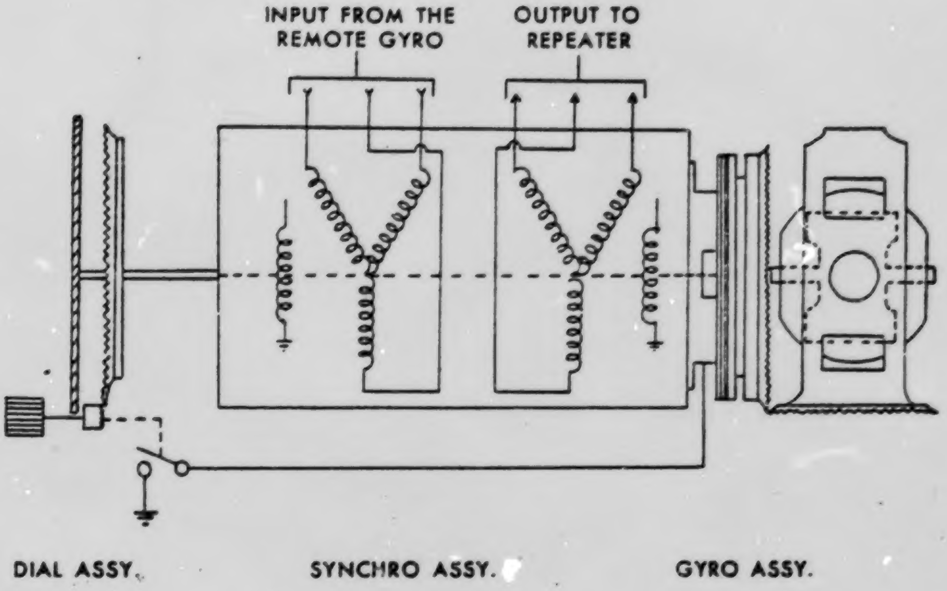
Answers to Frame 23: 1. horizontal 2. precession

Frame 25

Operation of the Directional Gyro Indicator will be covered in three parts:

1. Gyro assembly.
2. Synchro assembly.
3. Front panel (dial) assembly.

Refer to the drawing below to learn the three major parts of the indicator.


INPUT FROM THE REMOTE GYRO
OUTPUT TO REPEATER
DIAL ASSY.
SYNCHRO ASSY.
GYRO ASSY.

List in the spaces provided below, the three major parts of the Directional Gyro Indicator.

1. ______________________________.

2. ______________________________.

3. ______________________________.

Answers to Frame 24: 1. rigidity 2. dial

Frame 26

The gyro assembly contains the gyro. The gyro provides the stable reference for obtaining heading and turn signals. This heading information is sent mechanically through the synchro assembly and to the indicator dial.

Complete the statements below by underlining the correct answer(s).

1. The gyro is located in the (dial, chassis, synchro) assembly.

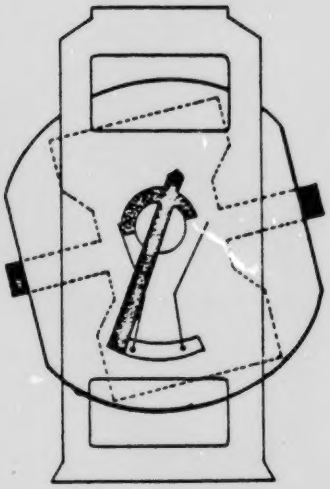
2. The (indicator dial, gyro) provides a stable reference for turn information.

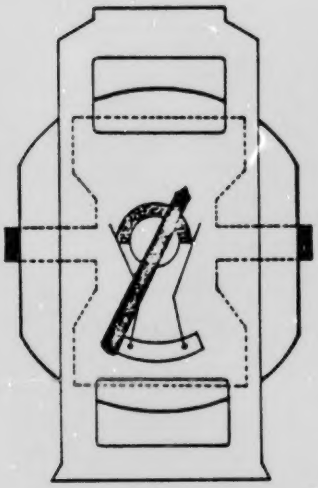
Answers to Frame 25: 1. gyro assembly 2. synchro assembly

3. dial assembly

Frame 27

The gyro spin axis is held parallel to the earth by a leveling device. This unit senses when the spin axis of the gyro has drifted from level. When the gyro is not parallel to the earth, the leveling devices apply power to a torque motor. Through the gyroscopic principle of precession, the gyro is driven back to level.





Complete the statements below by underlining the correct answer(s).

1. The gyro spin axis is held (parallel, perpendicular) to the earth.

2. When the gyro spin axis drifts from level, power is applied to a (torque motor, synchro).

3. The gyroscopic principle of (rigidity, precession) drives the gyro back to level.

1578

Answers to Frame 26: 1. chassis 2. gyro

Frame 28

In the diagram below, Figure B shows a directional gyro that is level. Notice that the two hairsprings are touching the half circle conductor (slip ring) that is mounted between the gyro case and outer gimbal. Leveling does not occur at this time because both brushes (hairsprings) are contacting the slip ring. Figure A shows that leveling is taking place because the gyro spin axis is not parallel to the earth. Notice that only one brush is touching the slip ring. This causes the torque motor to operate which precesses the gyro back to level. When the gyro is again level, both brushes contact the slip ring and the torque motor stops operating.

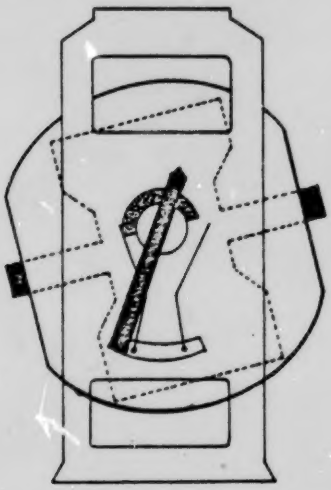


Figure A

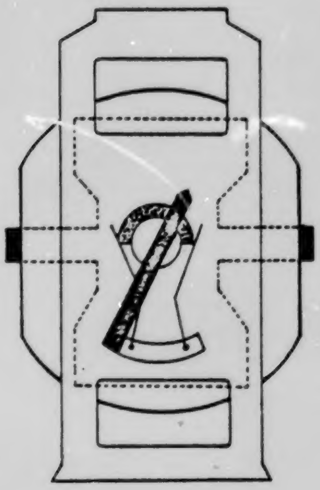


Figure B

Complete the statements below by underlining the correct answer(s).

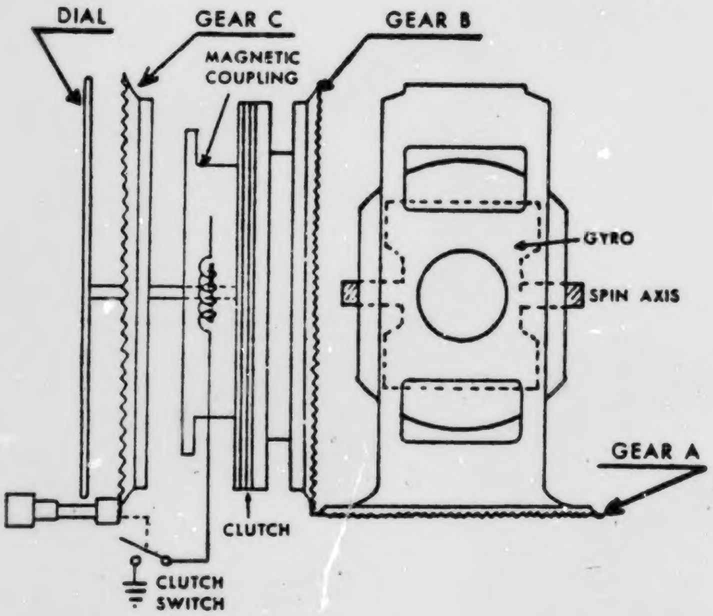
1. Torquing occurs when (one brush, both brushes) contact(s) the slip ring.

2. When the gyro is (level, unlevel), torquing occurs.

Answers to Frame 27: 1. parallel 2. torque motor 3. precession

Frame 29

A gear is mounted on the base outer gimbal of the gyro assembly (refer to gear A below). Gear A engages with a vertically mounted gear (gear B) in the synchro assembly. During aircraft turns the gyro and gear A hold a fixed position. As the aircraft turns around the gyro, motion is transferred to gear B. This motion from gear B is transmitted through the magnetic clutch to the indicator dial. Thus, as the aircraft turns mechanicl motion is transferred from the gyro to the dial which indicates the new heading. Gear C is used to set the dial to a magnetic heading without disturbing the position of the gyro. The procedure for setting the dial is covered in a later frame.



Complete the statements below by underlining the correct answer(s).

1. As the aircraft turns, the gyro assembly gear A (turns, remains fixed).

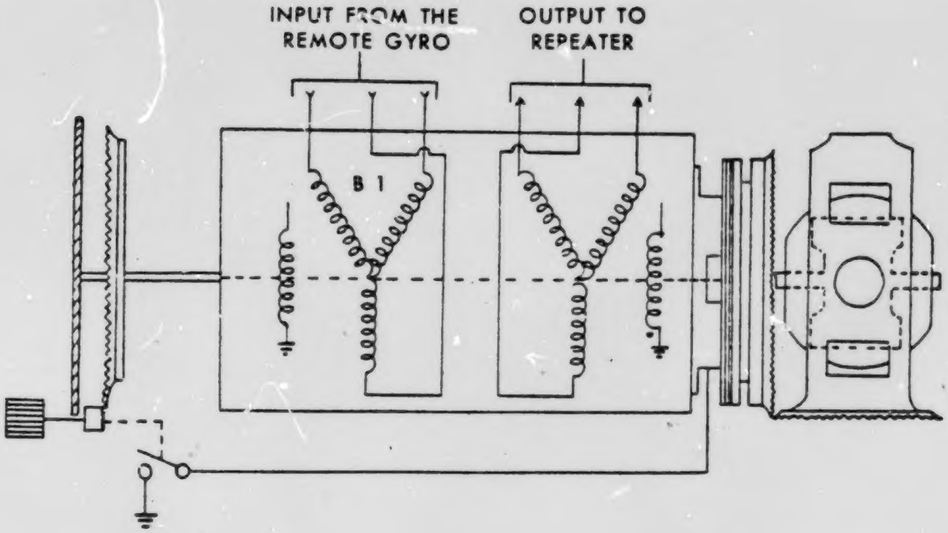
2. Gear B (turns, remains fixed) as the aircraft turns.

1580

Answers to Frame 28: 1. one brush 2. unlevel

Frame 30

The synchro assembly in most cases is not used. This assembly enables the Directional Gyro Indicator to be used as a repeater indicator. As a repeater, the indicator gyro is not used. The indicator dial will operate from an input signal from a gyro located at a different location in the aircraft. The input signal from a remote gyro would be applied to the stator windings of synchro B1 in the synchro assembly (refer to the diagram). The synchro stator will cause the rotor to be repositioned. The rotor of synchro B1 is mechanically linked to the indicator dial, causing it to turn as the aircraft heading changes.



Complete the following statements below by underlining the correct answer(s).

1. The Directional Gyro Indicator (can, cannot) be used as a repeater indicator.

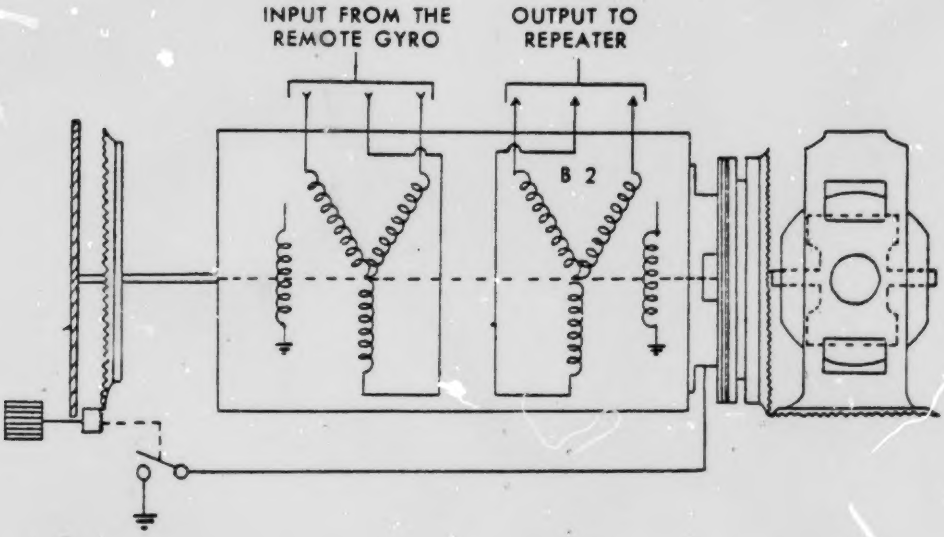
2. As a repeater indicator, signals would come from (inside the indicator case, a remote gyro).

1653

Answers to Frame 29: 1. remains fixed 2. turns

Frame 31

The synchro assembly also contains a transmitting synchro, B2 (refer to diagram). This synchro (B2) provides the Directional Gyro Indicator with the capability to provide an output (heading) signal to a repeater indicator located in some other part of the aircraft. As the aircraft turns, the mechanical motion which is transmitted through the synchro assembly to the dial, also repositions the rotor of B2. The rotor of B2 changes this mechanical motion into an electrical signal in the stators of B2. This signal can be transmitted to another indicator which will indicate the same heading as the Directional Gyro Indicator.



Complete the statements below by underlining the correct answer(s).

1. Synchro (B1, B2) enables the indicator gyro to operate repeater indicators.

2. The rotor of B2 changes a mechanical motion to an (electrical, input) signal.

Answers to Frame 30: 1. can 2. a remote gyro

Frame 32

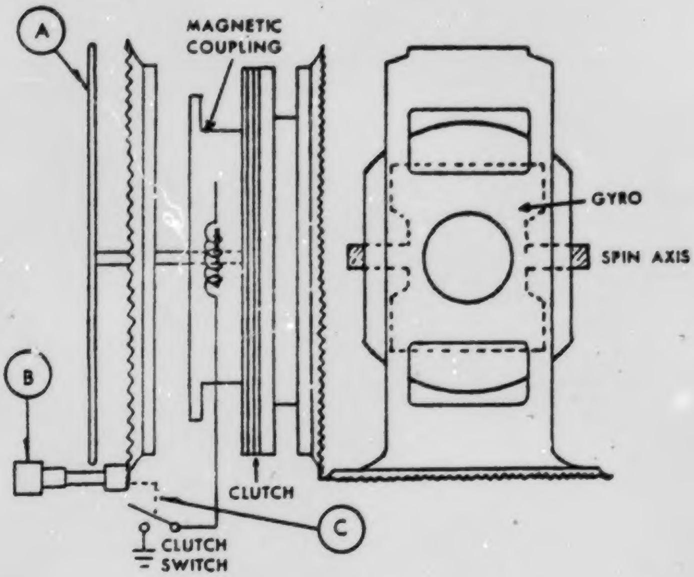
The dial assembly consists of the:

1. Dial (A in illustration below).

2. Push-to-set knob (B).

3. Clutch switch (C).

The dial provides an indication of the aircraft heading. To be accurate, the dial must be set to the correct heading. The pilot must be able to set the dial without affecting the position of the gyro. When setting the dial to the correct aircraft heading, the mechanical linkage between the gyro and the dial must be disengaged.



Place a checkmark (✓) in front of the true statements below.

_____1. To obtain accuracy when reading the indicator, the gyro must be set to the correct heading.

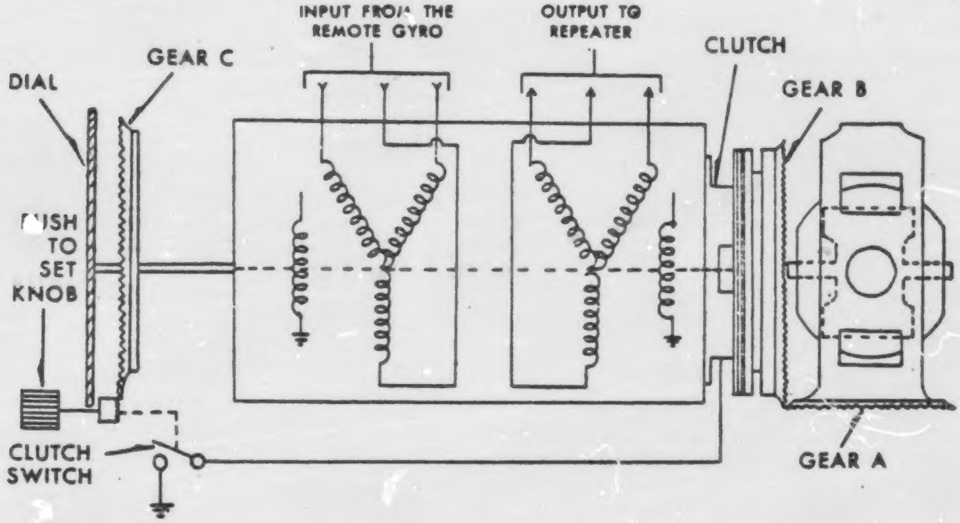
_____2. When setting the dial, the position of the gyro must not be affected.

_____3. When setting the dial, the mechanical linkage between the dial and gyro is engaged.

Answers to Frame 31: 1. B2 2. electrical

Frame 33

When the push-to-set knob on the front of the indicator is pushed in, a set of contacts (clutch switch) is closed. Closing the clutch switch energizes the magnetic clutch (refer to diagram). With the clutch energized, turning the knob causes gear C to turn. As gear C turns the indicator dial also turns without affecting the position of the gyro.


INPUT FROM THE REMOTE GYRO
OUTPUT TO REPEATER
GEAR C
DIAL
CLUTCH
GEAR B
PUSH TO SET KNOB
CLUTCH SWITCH
GEAR A

Complete the statements below by underlining the correct answer(s).

1. Pushing the push-to-set knob energizes (gear A, magnetic clutch, gyro).

2. Pushing and turning the knob rotates the (gyro and gear A, dial and gear C).

1584

Answers to Frame 32: ____1. _✓_2. ____3.

Frame 34

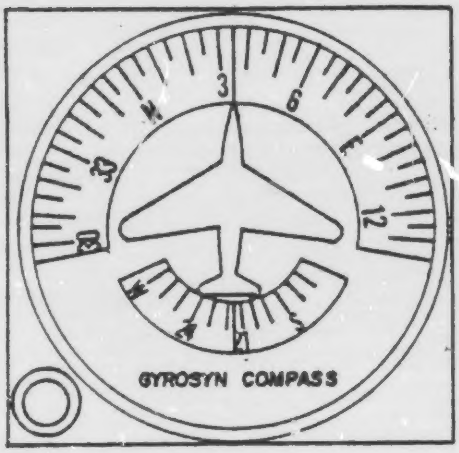
The indicator dial is read, simply by looking at the letter, number, or increment directly in line with the top lubber line. The dial should first be set to the magnetic heading of the aircraft. After the dial is set, it will rotate the same number of degrees that the aircraft turns.

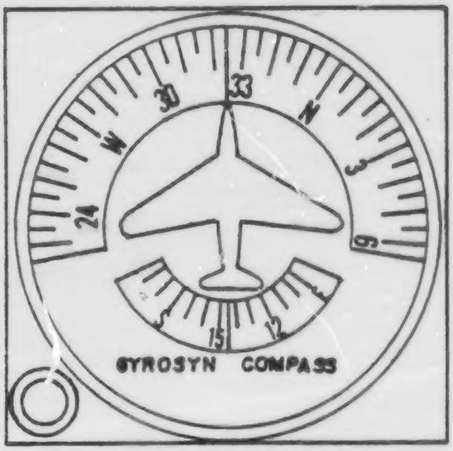
Complete the following statements by underlining the correct answer.

1. Aircraft heading is read at the (bottom lubber line, top lubber line, cardinal headings only).

2. The dial turns the same number of degrees as the (aircraft, gyro) turns.

Study the figures below, read the dial indications and write the indications below each illustration.





A __________________

B __________________

1657

1585

Answers to Frame 33: 1. magnetic clutch 2. dial and gear C

Frame 35

Place a checkmark (✓) in front of the true statements below.

_____1. The Directional Gyro Indicator provides a visual indication of aircraft heading.

_____2. The Directional Gyro Indicator uses the earth's magnetic field as a directional reference.

_____3. The indicator dial contains increments at every five degrees.

_____4. The purpose of the push-to-set knob is to reposition the gyro.

_____5. During normal operation, the gyro controls the position of the dial.

Complete the following statements by underlining the correct answer(s).

6. The (top, bottom) lubber line provides the reference for reading aircraft heading.

7. The (gyro, dial) turns the same amount that the aircraft turns.

In the spaces provided below, list the names of the three major parts of the Directional Gyro Indicator.

8. ________________________.

9. ________________________.

10. ________________________.

1658

Match the indicator parts to their function or purpose by placing the appropriate letter from Column II in the proper space provided in Column I.

Column I

_____11. Synchro assembly

_____12. Gyro assembly

_____13. Push-to-set knob

_____14. Dial

_____15. Magnetic clutch

Column II

a. Enables the dial to be positioned manually.

b. Is energized when the push-to-set knob is depressed.

c. Gives the indicator the capability of being a repeater.

d. Contains the directional reference gyro.

e. Contains increments at every 5 degrees for reading direction.

f. Reference from which the dial is read.

Answers to Frame 34: 1. top lubber line 2. aircraft

A. 035 degrees B. 325 degrees

Answers to Frame 35: ✓ 1. ___ 2. ✓ 3. ___ 4. ✓ 5.

6. top 7. dial 8. dial assembly 9. synchro assembly

10. gyro assembly 11. c 12. d 13. a 14. e 15. b

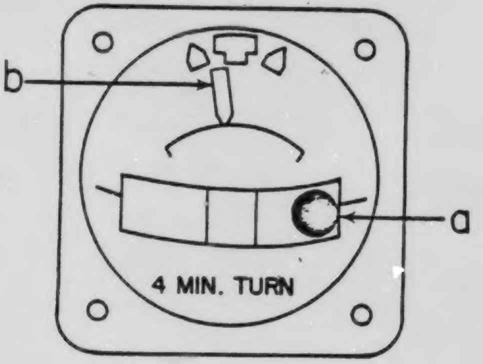
If any questions were missed in frame 35, return to the frames that cover the material that was missed and review it. After you have an understanding of the material covered in section C, ask your instructor the the appraisal.

Section D

BANK AND TURN INDICATOR

Frame 36

Bank and turn (turn and slip) indicators are basically designed as two instruments in one as shown below. There is an inclinometer (A) and a gyro operated turn indicator (B). The inclinometer provides a reference for the proper angle of bank in a coordinated turn. The gyro operated turn indicator provides an indication of rate of turn in degrees per minute and the direction (left or right) of turn.



NO RESPONSE REQUIRED

1661

1589

The purpose of the bank and turn indicator is to indicate the rate of turn in degrees per minute and to indicate the coordination between the angle of bank and the rate of turn.

Circle the letter(s) of the correct answers.

1. The bank and turn indicator indicates the

    a. direction of a turn.
    b. attitude of the aircraft.
    c. rate of turn in degrees per minute.
    d. coordination between the angle of bank and the rate of turn.

1662

Answer to Frame 36: No response required.

Frame 38

The inclinometer shows the coordination between the angle of bank and the rate of turn. The inclinometer consists of four things. (See figure below.) They are:

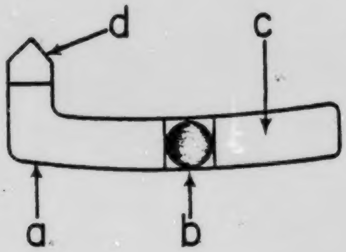
1. A glass tube (A).

2. A black glass ball (B).

3. Compass fluid to dampen the movement of the ball (C).

4. An expansion chamber to allow for expansion and contraction of the compass fluid with temperature changes (D).

The position of the black ball in the tube determines the coordination of the bank and turn.



Match the statements in Column A with the items in Column B by placing the correct letter in the place provided on the left.

A

_____1. Contains the compass fluid and black ball.

_____2. Dampens the ball's movement.

_____3. Allows the compass fluid to expand.

_____4. Indicates the coordination of the turn and bank.

B

a. Black glass ball

b. The glass tube

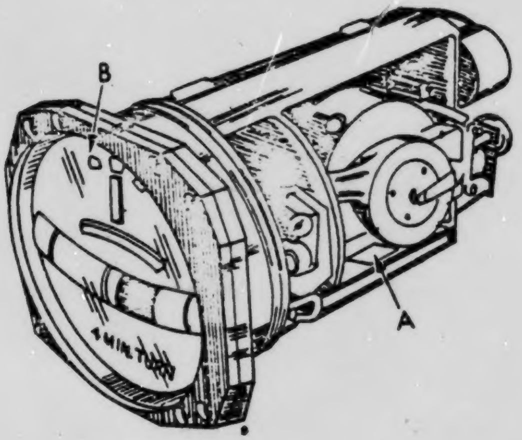
c. Compass fluid

d. Expansion chamber

Answers to Frame 37: 1. [✓ a] b [✓ c] [✓ d]

Frame 39

The gyro (A) that moves the turn pointer (B) is semiuniversally mounted (See figure below.) This gyro operates on the principle of precession. The power requirement for this gyro is 28V DC. The operating speed of the gyro is 5,200 rpm. This speed is controlled by a centrifugal governor.



Circle the letter(s) of the true statement(s) below.

a. The gyro in this instrument works on the gyroscopic principle of precession.

b. When the aircraft turns, the gyro should tilt.

c. The speed of the gyro is controlled by the centrifugal governor.

d. The gyro in this instrument operates on the gyroscopic principle of rigidity.

e. The power requirement for this gyro is 28V AC.

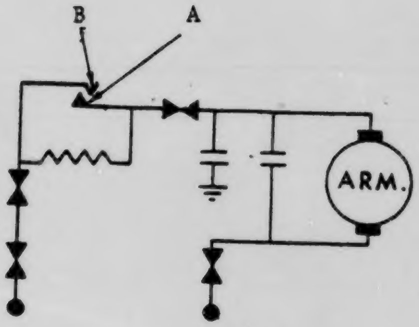
f. The operating speed of this gyro is 52,000 rpm.

1592

Answers to Frame 38: b 1. c 2. d 3. a 4.

Frame 40

The centrifugal governor shown in figure below controls the speed of the gyro. One of the governor's contacts is stationary (A); the other is a spring contact (B). The spring contact can be adjusted to increase or decrease the speed of the gyro.



Circle the letter(s) of the correct answer(s).

1. The purpose of the centrifugal governor is to control the

   a. movement of the ball.

   b. amount of gyro tilt.

   c. speed of the gyro.

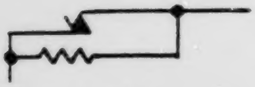
   d. amount of centrifugal force.

1665

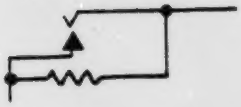
Answers to Frame 39: [✓ a] [✓ b] [✓ c] d e f

Frame 41

As long as the gyro rotor speed is 5,200 rpm or less, the governor contacts are closed. If the rotor speed exceeds 5,200 rpm, centrifugal force throws the spring contact outward. (See figure below.) This opens the circuit resulting in decreased rotor speed. After the rotor slows to 5,000 rpm, the contacts are again closed. The opening of the governor contacts control the speed of the gyro to approximately 5,200 rpm. The governor can be adjusted to increase or decrease the speed of the gyro. This adjustment will be covered later in this text.



Governor contact closed.



Governor contact open.

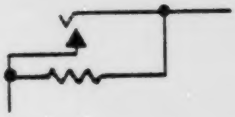
Circle the letter(s) of the true statement(s).

a. The speed of the gyro rotor is controlled by a centrifugal governor.

b. If the speed of the gyro exceeds 5,200 rpm, gravity opens the governor contacts.

c. As long as the rotor speed is 5,200 rpm or less, the governor contacts are closed.

d. The figure on the right shows the gyro's speed is 5,200 rpm or less.



Answers to Frame 40: a b [✓ c] d

Frame 42

Match the statements in Column A to the items in Column B by placing the letter of the item in the correct space on the left.

A

_____1. Indicates rate of turn and coordination.

_____2. Contains compass fluid and a black ball.

_____3. Dampens the ball's movement.

_____4. Allows the compass fluid to expand.

_____5. Indicates the coordination of the bank and turn.

_____6. Operates on the principle of precession.

_____7. Controls the speed of the gyro.

B

a. Black glass ball

b. Bank and turn indicator

c. Centrifugal governor

d. Glass tube

e. Compass fluid

f. Expansion chamber

g. Gyro

Answers to Frame 41: [✓ a] b [✓ c] d

Frame 43

When the aircraft turns, the gyro tilts, deflecting the pointer in the direction of the turn. The amount the pointer deflects from zero is proportional to the rate the aircraft is turning.

Circle the letter(s) of the correct answer(s).

1. The rate of turn is determined by the

    a. direction of pointer deflection.

    b. direction that the gyro tilts.

    c. amount of pointer deflection from zero.

    d. movement of the inclinometer.

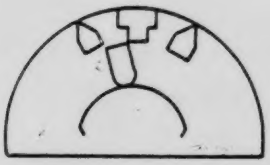
1596

Answers to Frame 42:

__b__ 1. __d__ 2. __e__ 3. __f__ 4. __a__ 5. __g__ 6. __c__ 7.

Frame 44

The width of the pointer is 5/32". One pointer deflection from zero is equal to a rate of turn of 90° per minute. (See figure below).



Circle the letters of the correct answers.

1. If the pointer on the bank and turn indicator is deflected 5/32" from zero, the aircraft's rate of turn is

   a. 180° per minute.

   b. 18° per minute.

   c. 90° per minute.

   d. 136° per minute.

2. Figure 6 indicates that the aircraft is turning at a rate of

   a. 190° per minute.

   b. 180° per minute.

   c. 18° per minute.

   d. 90° per minute.

Answers to Frame 43:

a b [✓ c] d

Frame 45

The pointer deflections must be read accurately by the instrument repairman. To make sure you understand, let's divide the pointer into five equal parts. Remember we said the width of the pointer is 5/32", and 5/32" is equal to 90° per minute. This means that 1/32" is 1/5 of 90° or 18°.

1. Convert the following fractions of an inch into degrees per minute.

a. 1/32" = ________ degrees per minute.

b. 2/32" = ________ degrees per minute.

c. 4/32" = ________ degrees per minute.

d. 5/32" = ________ degrees per minute.

e. 10/32" = ________ degrees per minute.

f. 1/8" = ________ degrees per minute.

g. 5/16" = ________ degrees per minute.

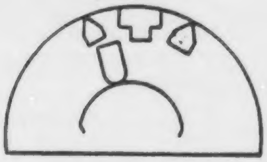
Answers to Frame 44:

1. a b [✓ c] d

2. a b c [✓ d]

Frame 46

Two pointer deflections are equal to 10/32" (2 x 5/32") or 180° per minute (2 x 90°). The figure below shows the aircraft turning at a rate which causes the pointer to deflect 1 and 1/2 pointer widths.



Circle the letters of the correct answers.

1. What is the aircraft's rate of turn in the figure above?
   a. 135°.
   b. 125°.
   c. 145°.
   d. 180°.

2. How many inches is the pointer in the figure above deflected?
   a. 13/64.
   b. 15/64.
   c. 17/64.
   d. 19/64.

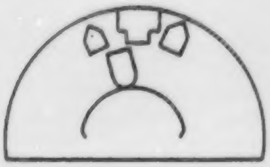
Answers to Frame 45:

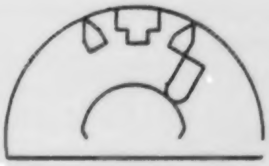
18 a. 36 b. 72 c. 90 d. 180 e. 72 f. 180 g.

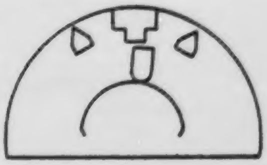
Frame 47

In the previous frame we converted 1 1/2 pointer deflections (widths) to 15/64" not ?/32". Why? 1 1/2 pointer widths = 1 1/2 x 5/32" = 3/2 x 5/32" = 15/64". Always remember that one pointer width is 5/32"; and if the pointer is deflected one width (5/32"), this is 90° per minute.

Read the indications below and indicate their readings in inches and degrees per minute.







1. a. ________" 2. a. ________" 3. a. ________"

b. ________°PM b. ________°PM b. ________°PM

1600

Answers to Frame 46:

1. [✓ a] b c d

2. a [✓ b] c d

Frame 48

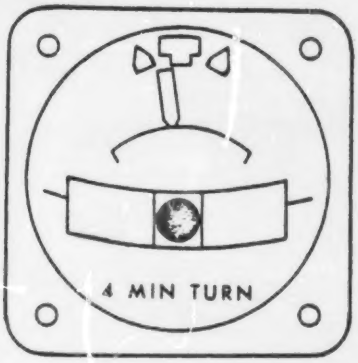
The inclinometer and pointer are read together to obtain the following information:

1. Coordinated turn.

2. Skid.

3. Slip.

During a turn, gravity and centrifugal forces act on the ball at the same time. If the aircraft is banked just the right amount for the rate of turn, both forces acting on the ball are equal. The ball then remains in the center. This is called a coordinated turn and is shown in the figure below.



Circle the letter(s) of the true statement(s).

a. The fluid in the inclinometer dampens the movement of the ball.

b. Gravity and centifugal forces act on the ball in a turn.

c. If gravity and centrifugal force are equal, the ball will remain in the center.

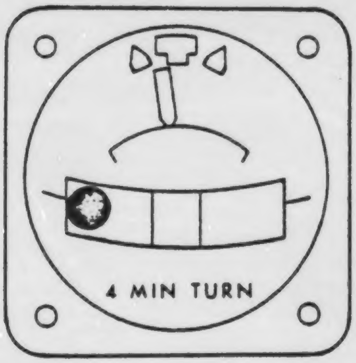
d. In a coordinated turn, the ball will stay in the center of the inclinometer.

Answers to Frame 47:

1.	a.	5/32"	2.	a.	15/32"	3.	a.	5/64"
	b.	90° PM		b.	270° PM		b.	45° PM

Frame 49

If the bank is too steep for the rate of turn, gravity overcomes centrifugal force and the ball falls towards the inside of the turn. This type of turn is called a slip and can be seen on the figure below.



Circle the letter(s) of the correct answer(s).

1. During a turn, if gravity overcomes centrifugal force the aircraft is

a. skidding.

b. making a coordinated turn.

c. turning too fast.

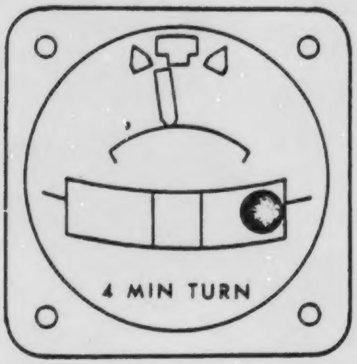
d. slipping.

Answers to Frame 48:

ⓐ ⓑ ⓒ ⓓ

Frame 50

If the angle of bank is too small for the rate of turn, centrifugal force overcomes gravity causing the ball to move to the outside of the turn. This type of turn is called a skid and can be seen on the figure below.



Circle the letter(s) of the correct answer(s).

1. During a turn, if centrifugal force overcomes gravity the aircraft is

   a. slipping.

   b. making a coordinated turn.

   c. skidding.

   d. turning too slow for the angle of bank.

Answers to Frame 49:

a b c [✓ d]

Frame 51

Circle the letters of the true statements below.

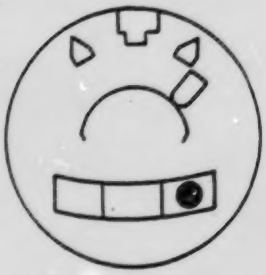
1. In a coordinated turn,

   a. gravity and centrifugal forces are equal.

   b. the ball remains centered.

   c. the pointer indicates the direction and rate of turn.

   d. the picture on the right would indicate a coordinated turn.



2. In a slip, the

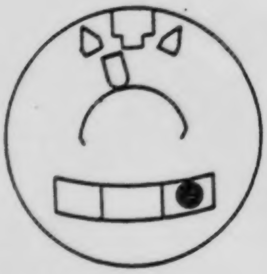
   a. angle of bank is too steep for the rate of turn.

   b. gravity overcomes (is greater) centrifugal force.

   c. ball "falls" toward the inside of the turn.

   d. pointer indicates the direction and rate of turn.

   e. indication would be the same as on the indicator on the right.



3. In a skid, the

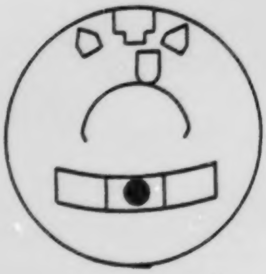
   a. angle of bank is too small for the rate of turn.

   b. centrifugal force overcomes (is greater) gravity.

   c ball is "thrown" to the outside of the turn.

   d. pointer indicates the direction and rate of turn.

   e. picture on the right would indicate a skid.



1604

Answers to Frame 50:

a b [✓ c] d

Frame 52

In the spaces provided:

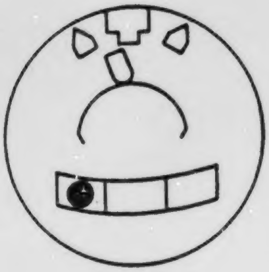
a. Indicate whether the bank and turn indicator shows a slip, a skid, or a coordinated turn.

b. Indicate the amount of pointer deflection in fractions of an inch.

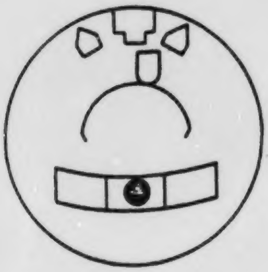
c. Indicate the rate of turn in degrees per minute.

1

a. ______
b. ______
c. ______



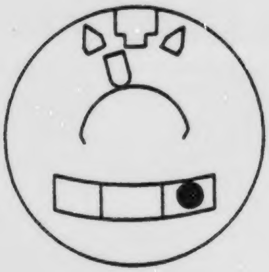
2



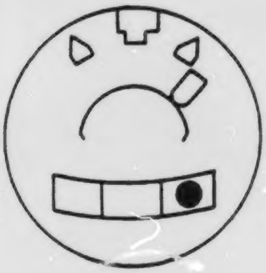
a. ______
b. ______
c. ______

3

a. ______
b. ______
c. ______



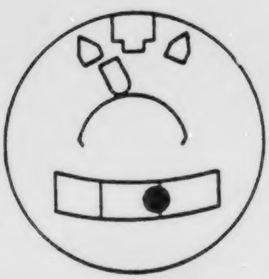
4



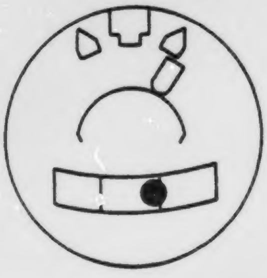
a. ______
b. ______
c. ______

5

a. ______
b. ______
c. ______



6



a. ______
b. ______
c. ______

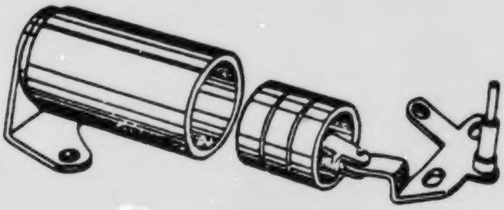
1677

Answers to Frame 51:

1. [✓ a] [✓ b] [✓ c] d
2. [✓ a] [✓ b] [✓ c] [✓ d] e
3. [✓ a] [✓ b] [✓ c] [✓ d] e

Frame 53

A dashpot type damping unit (shown in the illustration below) controls oscillation of the gyro. It acts as a brake of the gyro assembly for controlling the speed that the gyro returns to its neutral position after a turn. The damping unit is necessary to prevent the pointer (controlled by gyro movement) from returning too fast and overshooting the zero mark (pointer oscillation).



Circle the letter(s) of the correct answer(s).

1. The purpose of the damping unit is to

   a. prevent pointer oscillation.

   b. prevent inclinometer oscillation.

   c. keep the gyro rigid.

   d. keep the ball centered.

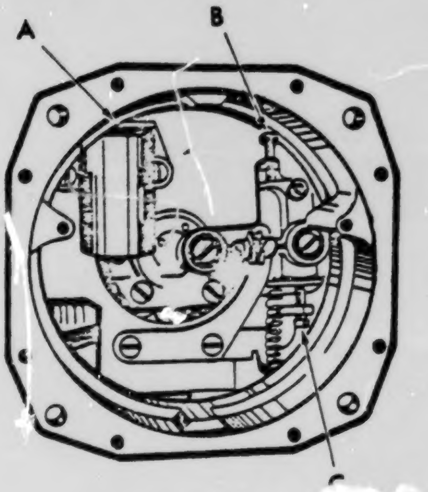
1606

Answers to Frame 52:

	1.	2.	3.	4.	5.	6.
a.	slip	co-ord	skid	slip	skid	slip
b.	5/32"	5/64"	5/32"	15/32"	15/64"	25/64"
c.	90°PM	45°PM	90°PM	270°PM	135°PM	225°PM

Frame 54

Sensitivity, damping, centering (static balance), and centrifugal governor adjustments can be made on the bank and turn indicator. The locations of the adjustment screws (not necessarily the screws themselves) are shown in the figure on the right (looking from the front of the instrument).



a. Item A is the damping adjustment screw.

b. Item B is the sensitivity adjustment screw.

c. Item C is the centering (static balance) adjustment screw.

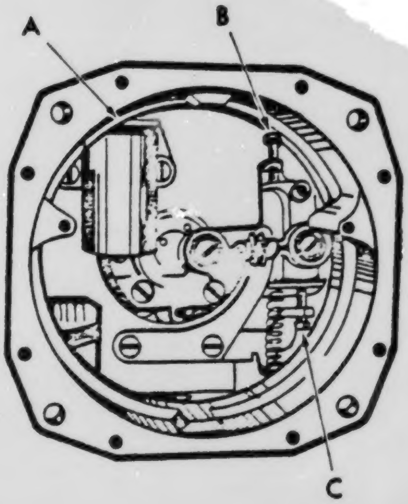
Study the locations again. Be sure you know the name and location of each adjustment screw.

Match the names of the adjustments with the letters shown in the figure below.

1. _____ Sensitivity adjustment screw.

2. _____ Centering adjustment screw.

3. _____ Damping adjustment screw.



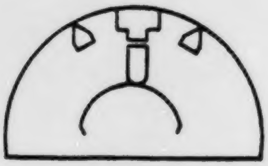
1679

Answers to Frame 53:

[✓ a] b c d

Frame 55

The purpose of the centering adjustment is to align the pointer on zero. This adjustment is performed with the instrument cover removed and with no power applied to the instrument.



Pointer Aligned on Zero.

Circle the letter(s) of the correct statement(s).

a. The centering adjustment is performed with power applied to the instrument.

b. The purpose of the centering adjustment screw is to align the pointer on zero.

c. The centering adjustment is performed with no power applied.

d. The centering adjustment controls pointer oscillation.

e. The centering adjustment is performed with the instrument cover on.

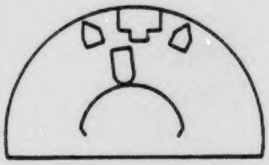
1608

Answers to Frame 54:

1. B 2. C 3. A

Frame 56

The purpose of the sensitivity adjustment screw is to adjust the pointer to indicate the correct rate of turn.



Pointer Adjusted to Indicate 90°PM.

Circle the letter(s) of the correct statement(s).

a. The sensitivity adjustment screw is used to adjust the pointer on zero.

b. The sensistivity adjustment is located on the upper left side (looking from the front).

c. The sensitivity adjustment is used to adjust the pointer to indicate the correct rate of turn.

d. The sensitivity screw is located on the upper right side of the instrument.

Answers to Frame 55:

a [✓ b] [✓ c] d e

Frame 57

The damping adjustment screw adjusts the rate at which the gyro returns to its neutral position. This prevents pointer oscillation and/or overtravel when the aircraft returns to level flight after making a turn.

Circle the letter(s) of the correct answer(s).

1. The purpose of the damping adjustment (screw) is to

   a. prevent inclinometer oscillation.

   b. keep the gyro level.

   c. adjust the pointer on zero.

   d. prevent pointer oscillation and/or overtravel.

Answers to Frame 56:

a b [✓ c] [✓ d]

Frame 58

The centrifugal governor adjustment screw is located on the gyro rotor. The purpose of this adjustment is to adjust the speed of the rotor at 5,200 rpm.

Circle the letter(s) of the correct statement(s).

a. The centrifugal adjustment screw is located on the upper left side of the instrument.

b. The centrifugal governor adjustment screw is used to adjust the speed of the rotor.

c. The rate of turn, indicated by the pointer, is controlled by the centrifugal governor adjustment.

Answers to Frame 57:

a b c [✓ d]

Frame 59

Match the items in the right hand column to those in the left.

1._____ used to align the pointer on zero.

2._____ adjusts rotor speed.

3._____ used to adjust the pointer to indicate the correct rate of turn.

4._____ used to prevent pointer oscillation and/or overtravel.

5._____ located on the upper right side of the indicator.

a. Damping adjustment screw

b. Centrifugal governor adjustment

c. Sensitivity adjustment screw

d. Centering adjustment screw

e. Inclinometer

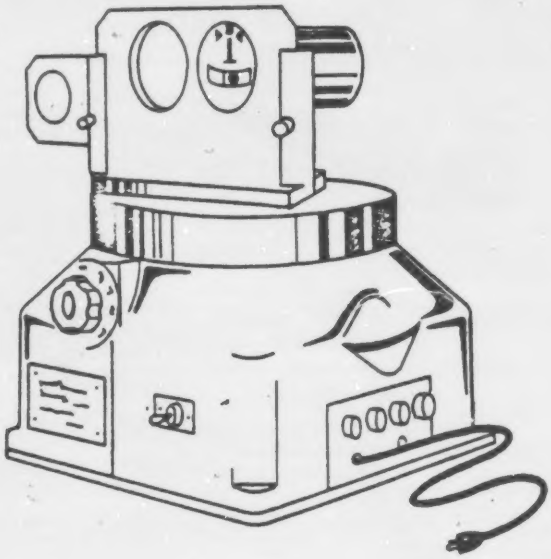
f. Gyro

Answers to Frame 58:

a [✓ b] c

Frame 60

An instrument test turntable as shown in the figure below, is used for bench checking all bank and turn indicators. The turntable is equipped with special brackets that enable you to mount the indicator in the same position it will occupy in the aircraft. The turntable is used to simulate five correct rates of turn. The turntable must be checked periodically to make sure these simulated rates are correct.



Circle the letter(s) of the correct answer(s).

1. The purpose of the instrument test turntable is to

   a. dampen pointer oscillation.

   b. simulate the correct amount of turn.

   c. simulate the correct rate of turn.

   d. check the speed of the gyro.

Answers to Frame 59:

1. d 2. b 3. c 4. a 5. c

Frame 61

The starting voltage, damping, current drain and sensitivity tests are all performed with power applied to the instrument.

The starting voltage test is performed by applying the 15V DC to the instrument and checking to see if the rotor starts to rotate and continues to rotate. The purpose of this test is to check for excessive friction in the rotor bearings of interference between the rotor and the stator.

Circle the letter(s) of the correct answer(s).

1. The starting voltage test is performed to

a. check for interference in the 15V DC.

b. check for excessive rotor bearing friction or interference between the rotor and the stator.

c. simulate excessive bearing friction and stator rubbing.

1614

Answers to Frame 60:

a b [✓ c] d

Frame 62

The current drain (power consumption) test is performed by placing an ammeter in series with the instrument power input and checking for a maximum amperage of 150 milliamperes. If the current exceeds 150 milliamperes, the probable cause is excessive rotor bearing friction.

Circle the letter(s) of the correct answer(s).

1. The primary purpose of the current drain test is to

   a. measure 150 milliamperes.

   b. place the ammeter in series.

   c. check the condition of the rotor bearings.

   d. check rotor speed.

Answers to Frame 61:

a [✓ b] c

Frame 63

The damping test is performed by mounting the indicator on the turntable and allowing the rotor to rotate at full operating speed. Rotate the turntable at 3 rpm (1080°PM). Suddenly stop the rotation of the turntable. The pointer should settle on the "zero" position in not less than 1 second or more than 3 seconds. If the pointer oscillates, overtravels, or appears sluggish, the damping adjustment must be made. If the pointer should oscillate or overtravel, it is returning too fast (in less than one second). If the pointer appears sluggish, it is returning too slowly (more than 3 seconds).

Circle the letter(s) of the true statement(s).

a. The turntable should be operated at 3°PM for the damping test.

b. The pointer should return to zero within 1 to 4 seconds.

c. The oscillations of the pointer should be counted.

d. The purpose of the damping test is to check for pointer oscillations, overtravel and sluggishness.

Answers to Frame 62:

a b [✓ c] d

Frame 64

The sensitivity test is performed using the turntable to simulate the rates of turn given in the technical order. The purpose of this test is to check the instrument to make sure it is indicating the correct rate of turn.

NO RESPONSE REQUIRED

Answers to Frame 63:

a b c [✓ d]

Frame 65

I. Circle the letter of the true statements below.

a. The bank and turn indicator measures turns in degrees per second.

b. Direction of turn is indicated by the bank and turn indicator.

c. The degree an aircraft has turned is indicated by the bank and turn indicator.

d. The bank and turn indicates the coordination between the angle of bank and the rate of turn.

e. Rate of turn is indicated in degrees per minute.

II. Match the bank and turn indicator parts to their function by placing the letters of the parts in Column II in the appropriate spaces in Column I.

Column I	Column II
____1. Adjusts the pointer to the correct rate of turn.	a. Compass fluid.
____2. Aligns the pointer to center	b. Centering adjustment.
____3. Allows the compass fluid to expand.	c. Centrifugal governor.
____4. Controls the rate at which the pointer returns to center.	d. Dampening adjustment.
____5. Controls the speed of the gyro.	e. Expansion chamber.
____6. Contains the compass fluid.	f. Glass ball.
____7. Dampens the movement of the glass ball.	g. Glass tube.
____8. Has its speed adjusted to 5200 rpm.	h. Gyro.
____9. Indicates the coordination of the bank and turn.	i. Sensitivity adjustment.

___10. Operates on the principle of precession.

III. In the spaces provided:

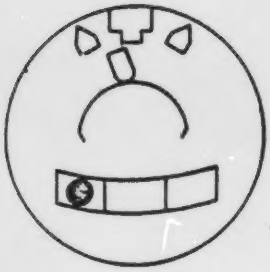
a. Indicate whether the bank and turn indicator shows a slip, a skid, or a coordinated turn.

b. Indicate the rate of turn in degrees per minute.

1

a. ______

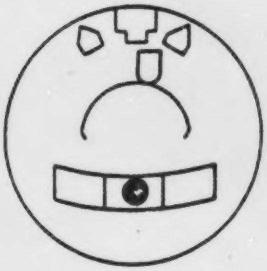
b. ______



2

a. ______

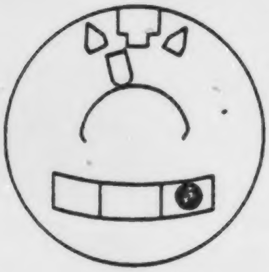
b. ______



3

a. ______

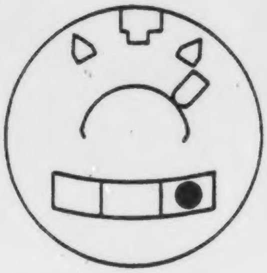
b. ______



4

a. ______

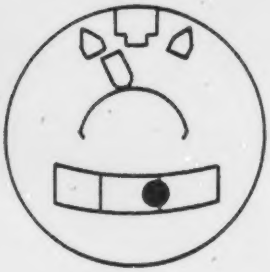
b. ______



5

a. ______

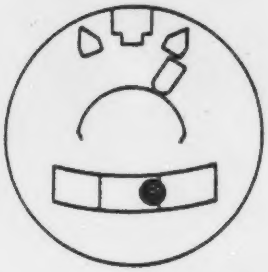
b. ______



6

a. ______

b. ______



Answers to Frame 65:

I. a [✓ b] c [✓ d] [✓ e]

II. i 1., b 2., e 3., d 4., c 5., g 6., a 7., h 8., f 9., h 10.

III.

	1.		2.
a.	slip	a.	co-ord
b.	90°PM	b.	45°PM
	3.		4.
a.	skid	a.	slip
b.	90°PM	b.	270°PM
	5.		6.
a.	skid	a.	slip
b.	135°PM	b.	225°PM

If any questions were missed in frame 65, return to the frames that cover the material that was missed and review it. After you have an understanding of the material presented in section D, ask your instructor for the appraisal.

WORKBOOK
3ABR32531-WB-402

Technical Training

Avionics Instrument Systems Specialist

INSPECTION, BENCH CHECK AND ADJUSTMENT OF THE BANK AND TURN INDICATOR

17 March 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

1621

Flight Training Devices/Instrument Branch 3ABR32531-WB-402
Chanute AFB, Illinois

INSPECTION, OPERATIONAL CHECK, BENCH CHECK AND TROUBLESHOOT THE BANK AND TURN INDICATOR

OBJECTIVES

1. Given a workbook, test equipment and components, perform an inspection and operational check of flight instruments with a minimum of 100% accurate workbook responses.

2. Given a workbook, test equipment and components, perform a bench check of representative flight instruments with a minimum of 100% accurate workbook responses.

3. Given a workbook, test equipment and trainer, troubleshoot flight instruments with a minimum of 80% accurate workbook responses.

EQUIPMENT

	Basis of Issue
Rate Table	1/student
Power Control Panel	1/student
AN/PSM-6	1/student
Stroboscope	1/student
Screwdriver	1/student
Turn and Slip Indicator	1/student
Workbook	1/student

PROCEDURE

The instructions necessary for the performance of a visual inspection, operational check, bench check, and troubleshooting the turn and slip indicator are given in this workbook. As each step of this workbook is completed, you will be required to make some kind of a response. Your response may be placing a check (✓) on a blank to indicate satisfactory or unsatisfactory results or filling in a blank with a voltage or current value. After you have completed the workbook, your instructor will check it. If you have difficulty completing any part of the workbook, ask your instructor for assistance. REMOVE ALL YOUR JEWELRY!!!

1. Visual Inspection.

a. Make a thorough visual check of the turn and slip indicator to insure that the case, cover glass, and connector are not dented, cracked, or corroded. List any defects in the spaces below.

____

____

Supersedes 3ABR35231-WB-402, 27 March 1974.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 200; TTVSA - 1

b. Check the fluid in the inclinometer to ensure that it is not discolored (milky) and that there are no air bubbles in view.

Results Of Check			
S		U	

Note: If there are any air bubbles visible in the inclinometer they can be removed by tilting the indicator clockwise until the air has returned to the expansion chamber on the inclinometer. This can be done while doing step c.

c. Disconnect the cannon plug from the rear of the indicator and slide the face plate, with the indicator mounted on it, from the brackets on the turntable. Tilt the indicator left and right to ensure that the glass ball moves freely in the inclinometer. Replace the face plate in the holding brackets on the turntable, and the glass ball should center itself between the lines at the center of the inclinometer.

Results Of Check			
S		U	

d. Gently tap the indicator and check the pointer, it should be exactly aligned with the center mark on the dial.

Results Of Check			
S		U	

Note: If the pointer is not aligned with the center mark, you will make the proper adjustment later in this workbook.

2. Bench Check--This portion of the workbook will incorporate the operational check, bench check, and troubleshooting objectives.

Note: Before continuing, slide the case off of the indicator. Reconnect the cannon plug.

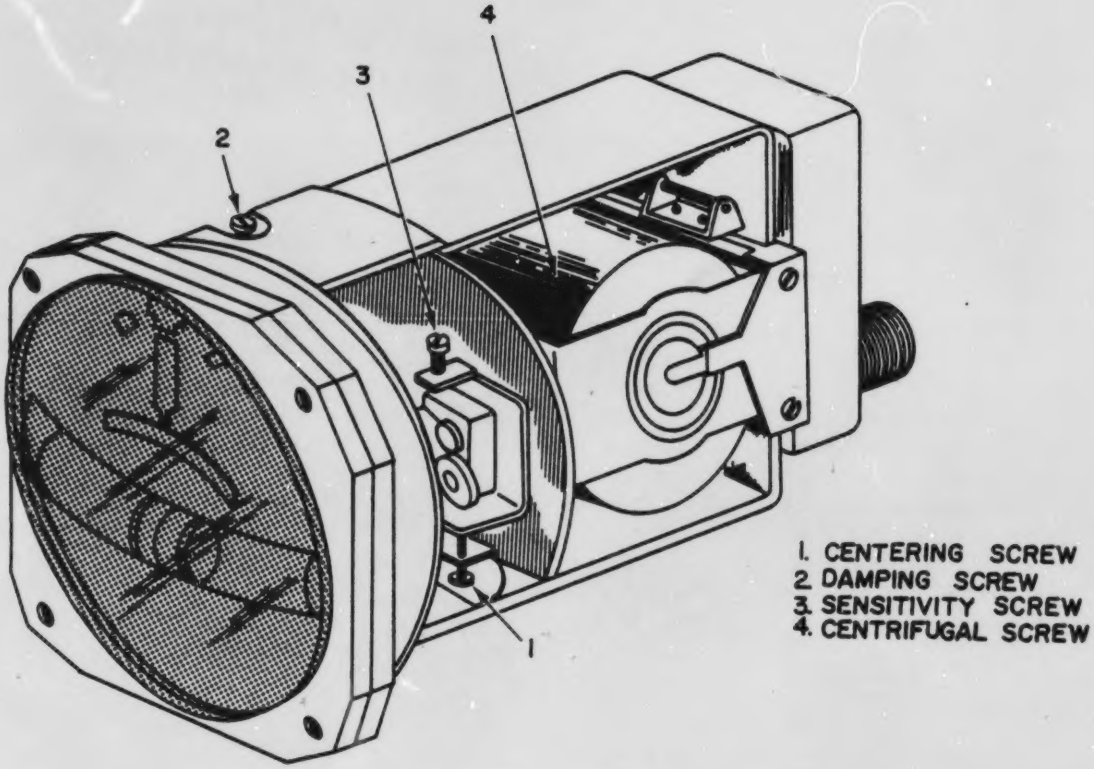
a. Static Balance Check.

(1) If you found that the pointer was not centered during the visual inspection, you can center it by turning the centering screw shown in figure 1.

(2) While you are turning the screw gently tap the indicator to remove any friction that may be in the mechanical linkage.

Results Of Check			
S		U	

1623



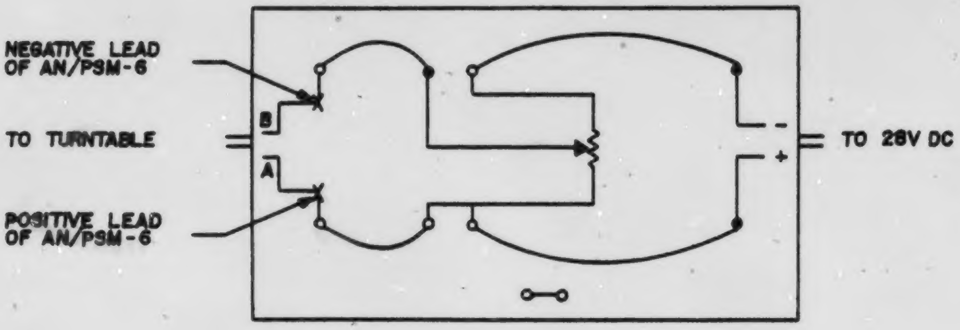
4
3
2
1
1. CENTERING SCREW
2. DAMPING SCREW
3. SENSITIVITY SCREW
4. CENTRIFUGAL SCREW

Figure 1. Location of Adjustment Screws.

b. Starting Voltage Check.

(1) Make sure that the turntable RATE CONTROL is in the OFF position. Plug the turntable into a 115V AC, single phase, 60Hz outlet.

(2) Wire the power control panel as shown in figure 2.



NEGATIVE LEAD OF AN/PSM-6
TO TURNTABLE
POSITIVE LEAD OF AN/PSM-6
B
A
-
+
TO 28V DC

Figure 2. Power Control Panel Wiring Diagram.

1636

(3) Prepare the AN/PSM-6 for making DC voltage measurements and connect it to the points indicated on the power control panel in figure 2. Be sure that you observe the polarities when making this hookup.

(4) Plug the cannon plug on the power control panel into the connector on the turntable.

(5) Rotate the potentiometer on the power control panel fully clockwise.

(6) Connect the power plug on the control panel into a 28V DC outlet.

(7) Watch the gyrorotor and slowly turn the potentiometer counterclockwise. When the rotor begins to turn, stop turning the potentiometer and record the voltage reading of the PSM-6. It is reading _______________ volts. This value should be 15 volts or less.

Results Of Check			
S		U	

(8) Unplug the control panel from the 28V DC outlet.

c. Current Drain Check.

(1) Wire the power control panel as shown in figure 3.

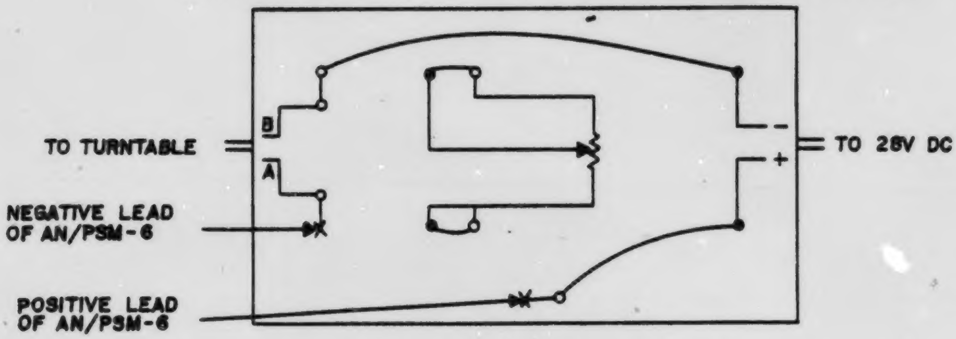


Figure 3. Power Control Panel Wiring Diagram.

(2) Prepare the AN/PSM-6 for making DC current measurements. Be sure to start this check with the range selector set to 1,000. Connect the PSM-6 to the points indicated on the control panel in figure 3. Be sure to observe polarity.

(3) Connect the power plug on the control panel to the 28V DC outlet.

(4) Watch the PSM-6. The current required to operate the gyro should not exceed 150 milliamps. The PSM-6 is reading __________ milliamps. Allow 5 seconds for the indication to stabilize.

Results Of Check			
S		U	

(5) Unplug the control panel from the 28V DC outlet.

d. Gyrospeed Check.

(1) Wire the power control panel as shown in figure 4.

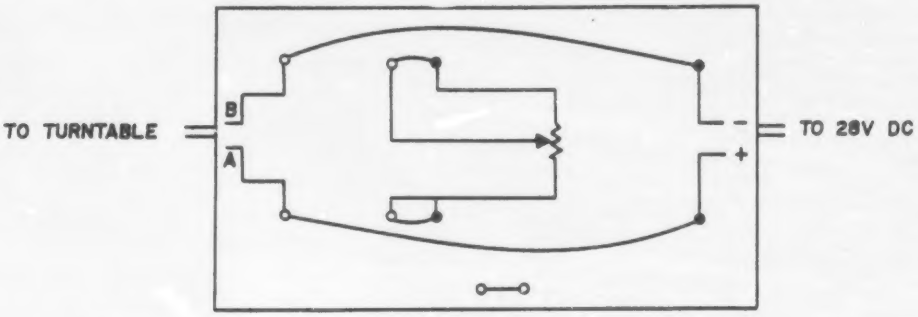


Figure 4. Power Control Panel Wiring Diagram.

(2) Connect the power plug on the control panel to a 28V DC outlet.

(3) On the stroboscope (refer to figure 5), place the select dial to the first STROBOSCOPE HIGH position. Plug the power cord of the stroboscope into a 115V AC, single phase, 60Hz outlet. The stroboscope light should begin to flicker, if it doesn't, call your instructor.

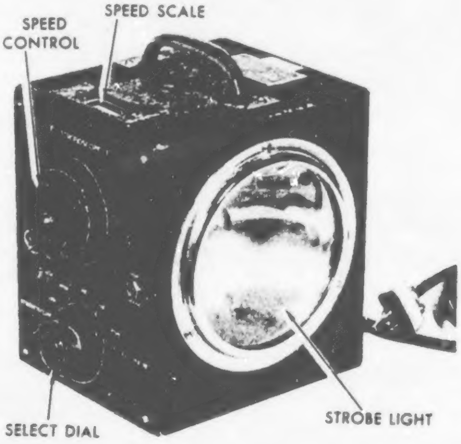


Figure 5. Stroboscope.

(5) Place the stroboscope next to the gyro so that the light flickers on the gyro. Adjust the stroboscope speed control knob until the gyro appears to be stopped. Read the speed of the gyro from the HIGH side of the speed scale on top of the stroboscope. The speed should be 5,200 RPM ± 100 RPM. Record the speed of the gyro on the space provided.

Results Of Check			
S		U	

________________________.

(6) Move the select dial on the stroboscope to OFF, and unplug the stroboscope.

e. Damping Check.

(1) Ensure that the power control panel is wired as shown in figure 4, and that it is plugged into a 28V DC outlet.

(2) Place the turntable directional control switch to either the L or R position, and the rate control knob to the 1,080 degree position.

Note: Watch the pointer closely as you perform the next step. The pointer must return to the center of the dial in no less than one second and no more than three seconds after the turntable has stopped.

(3) After the turntable has made a couple of revolutions, turn the rate control OFF. This will cause the table to stop turning instantly.

(4) If the pointer took less than one second, or more than three seconds, or overshot the center mark when returning, the damping screw, will have to be adjusted. See figure 1 for its location.

Results Of Check			
S		U	

(5) If you have to make the adjustment of the damping screw, repeat steps 2 through 4 until the damping check is satisfactory.

f. Sensitivity Check.

(1) Ensure that the power control panel is wired as shown in figure 4 and that it is connected to a 28V DC outlet.

(2) Turn the rate table rate control to 180 degrees per minute. The pointer should deflect 5/16 ± 1/32 of an inch.

(3) Record the pointer deflection on the blank provided.

____________________.

Results Of Check			
S		U	

(4) If the pointer is out of tolerance, adjust the sensitivity screw shown in figure 1.

(5) Test the indicator at the rates of turn given in table 1 below. Record the amount of deflection for each of the rates and indicate if it was satisfactory or unsatisfactory.

Rate of Turn	Pointer Deflection	Required Pointer	Results of Sat	Check Unsat
36 per min		1/16 ± 1/64		
180 per min		5/16 ± 1/32		
360 per min		5/8 ± 1/16		

Table 1. Sensitivity Check.

1700

g. Troubleshooting.

(1) Figure 6 contains data relative to locating troubles in the equipment, their probable causes, and corrective measures necessary to correct the problem.

Trouble	Probable Cause	Remedy
INDICATOR DRAWS EXCESSIVE CURRENT	Excessive friction in bearings.	Replace defective bearings.
	Weak motor magnet.	Replace magnet.
	Excessive preload on bearings.	Adjust motor adjusting nuts.
BALL REACTION SLUGGISH OR ERRATIC	Defective inclinometer.	Replace indicating assembly.
STATIC UNBALANCE OF GIMBOL	Improper adjustment of nuts.	Adjust nuts as required.
NEEDLE OFF CENTER	Improper adjustment of screw.	Adjust screw as required.
INDICATING POINTER APPEARS UNSTABLE	Unbalanced rotor.	Rebalance or replace rotor assembly as necessary.
	Loose linkage to pointer assembly.	Replace faulty parts.
	Insufficient damping.	Disassemble and check damping unit for cleanliness, reassemble and check adjustment.
	Excessive gyrorotor speed.	Decrease speed to recommended value.
INDICATOR POINTER SLUGGISH, LOW SENSITIVITY	Insufficient gyrorotor speed.	Increase rotor speed to recommended value.
	Excessive friction in rotor bearings.	Inspect and replace bearings as necessary.

Figure 6. Troubleshooting Data.

1629

(2) In the spaces provided below, using the information obtained during bench check procedures and using figure 6, list all troubles observed during bench check, probable causes of each trouble, and the necessary remedy to solve each trouble.

Trouble	Probable Cause	Remedy

Take your workbook to the instructor and have him check your entries. When he has checked them, disconnect all the equipment and return it to its proper storage place.

1702

1630

PROGRAMMED TEXT
3ABR32531-PT-401
3ABR32632B-PT-501

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

OPERATION OF MAGNETIC (STANDBY) COMPASS

16 May 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

1703

1631

FOREWORD

This programmed text was prepared for use in Courses 3ABR32531, Avionic Instrument Systems Specialist and 3ABR32632B, Integrated Avionic Systems Specialist. The material contained herein has been validated using 21 students from the subject course. At least 90% of the students achieved the objective as stated. The average time to complete the text was one hour and 45 minutes.

OBJECTIVE

Without references, identify facts pertaining to the purpose, operation and/or characteristics of direct reading compasses, with a minimum accuracy of 75%.

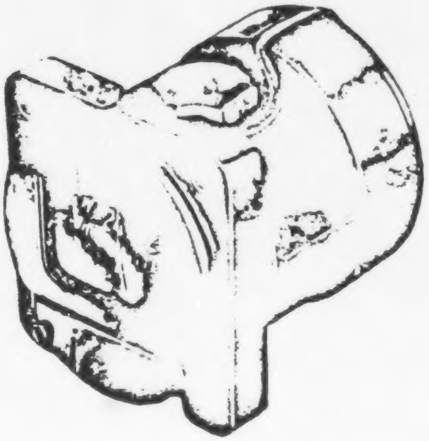
INSTRUCTIONS

This programmed text presents information in small steps called "frames." Each frame is followed by some form of questioning. Immediately after reading each frame, you will make the required response. Check your answers each time with the correct answers shown. The correct answers will be given below the following frame. If you made the correct response, go on to the next frame. If you made an incorrect response, read the frame again before going on to the next frame. Work as fast as you can but DO NOT HURRY. If you DO NOT understand any part of this text, ask your instructor for assistance.

Supersedes 3ABR32531-PT-401, 3ABR32632B-PT-401, 19 June 1974.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 200; TTVSA - 1

1632

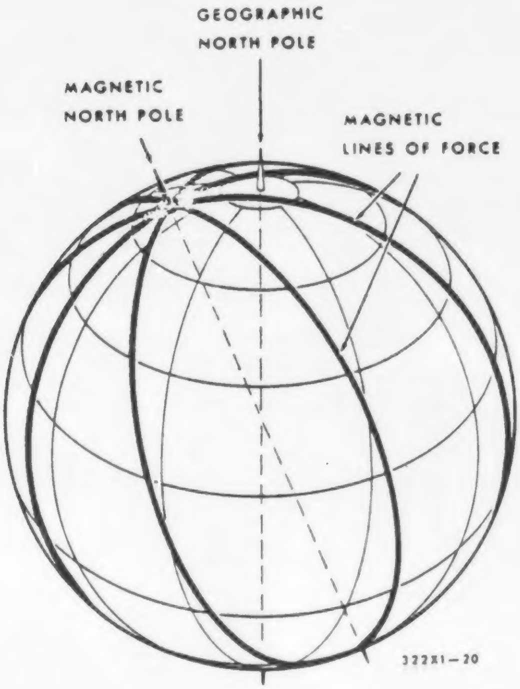
The magnetic (standby) compass (shown below) is a directional indicating instrument installed on all aircraft. It is located in the cockpit in full view of the pilot. On most aircraft it is only used in an emergency, such as electrical power failure or loss of other navigational aids.



No Response Required

Frame 2

The earth's magnetic field has lines of force that are parallel to the earth's surface except near the magnetic poles. (See figure below.) At the poles, they are perpendicular to the earth's surface. The reason for this is that they are entering the earth at this point just as they do in a bar magnet. The intensity of the magnetic field at the poles will be greater than at any other point on the earth's surface.



Circle the number preceding each true statement below.

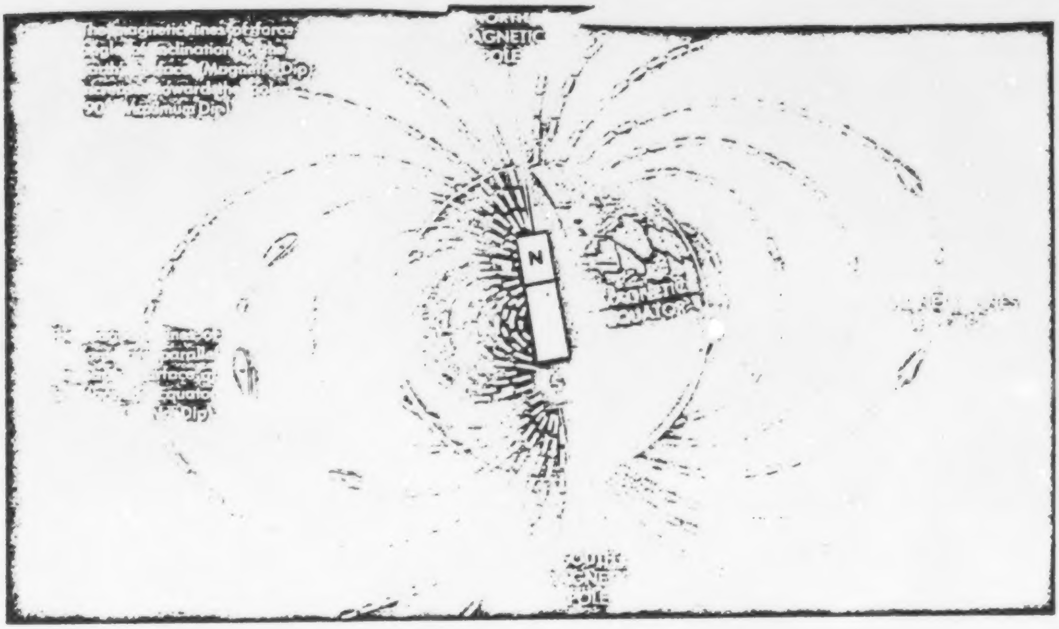
1. The magnetic lines of force are perpendicular to the earth at the equator.

2. The earth's magnetic field is parallel to the earth's surface except at the poles.

3. The strength of the earth's magnetic field is greater at the poles.

If a bar magnet were allowed to hang freely, it would tend to align itself with the magnetic lines of force of the earth. The end pointing at the north pole is the north seeking pole. This same principle is the principle of operation of the magnetic compass.

The magnetic (standby) compass uses two bar magnets which alig with the earth's magnetic lines of force. These lines of force run parallel to the earth near the equator and dip into the earth at the magnetic poles. Because the lines of force are perpendicular at the poles the compass in polar regions is not accurate above 70 degrees north or south latitude due to the magnetic dip. Refer to the illustration below.


The magnetic lines of force
(Magnetic Dip)
90° Maximum Dip)
NORTH
MAGNETIC
POLE
N
MAGNETIC
EQUATOR
parallel
equator
SOUTH
POLE

Circle the number preceding each true statement below.

1. Magnets in the standby compass align with the earth's magnetic force.

2. The standby compass is most accurate above 70 degrees north or south latitude.

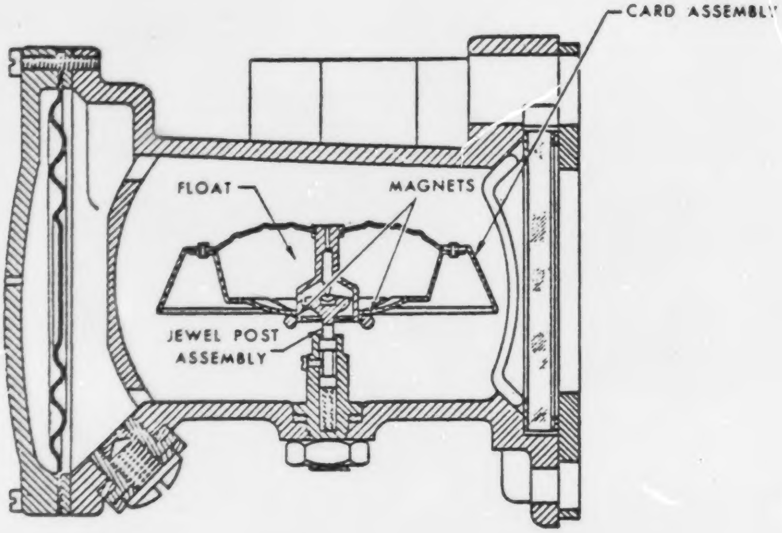
Answers to Frame 2: 2, 3.

1635

Frame 4

The direction seeking element of the pilot's magnetic (standby) compass consists of two small bar magnets attached to a float. Also attached to the float is a circular scale, or card, graduated in increments of 5 degrees from zero (0) to 360 degrees. The entire assembly is mounted on a jewel and pivot so that it is free to align itself horizontally with the earth's magnetic field.

Study the drawing below to determine how the float and card are mounted in the compass.



Circle the number preceding each true statement below.

1. The direction seeking elements in the compass are permanent magnets.

2. The scale mounted on the float assembly is graduated in 10 degree increments only.

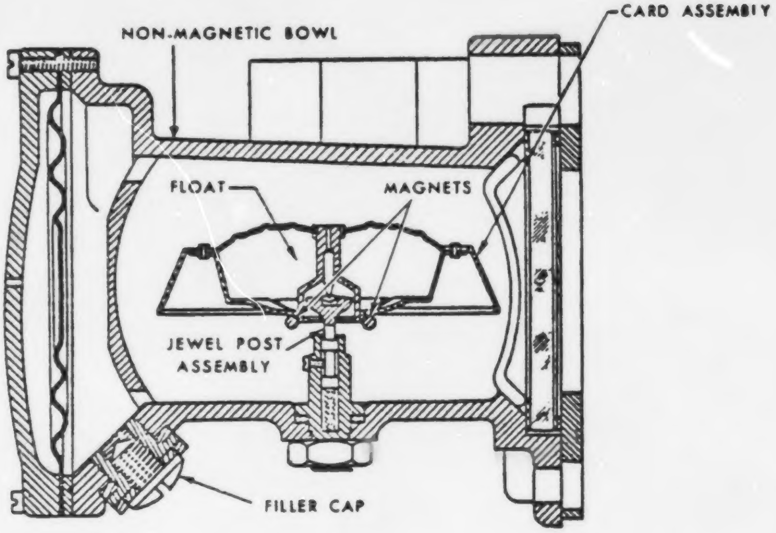
3. Bearings provide the mounting for the float assembly.

Answers to Frame 3: 1.

1708

The card and float assembly is placed in a nonmagnetic bowl filled with compass fluid. The compass fluid used is highly refined kerosene. This highly refined kerosene serves to dampen the oscillation of the float assembly and reduce friction at the pivot. A filler cap allows for filling the compass bowl with fluid. It is found on the top or bottom of the compass body.

Look at the drawing below to determine how the compass is filled with compass fluid.



Circle the number preceding each true statement below.

1. The compass fluid dampens the oscillation of the float assembly and lubricates the jewel pivot.

2. In order for the compass to function properly, the bowl must be magnetized.

3. The filler cap is located on the top or bottom of the compass body.

4. The filler cap provides a means of filling the compass body with fluid.

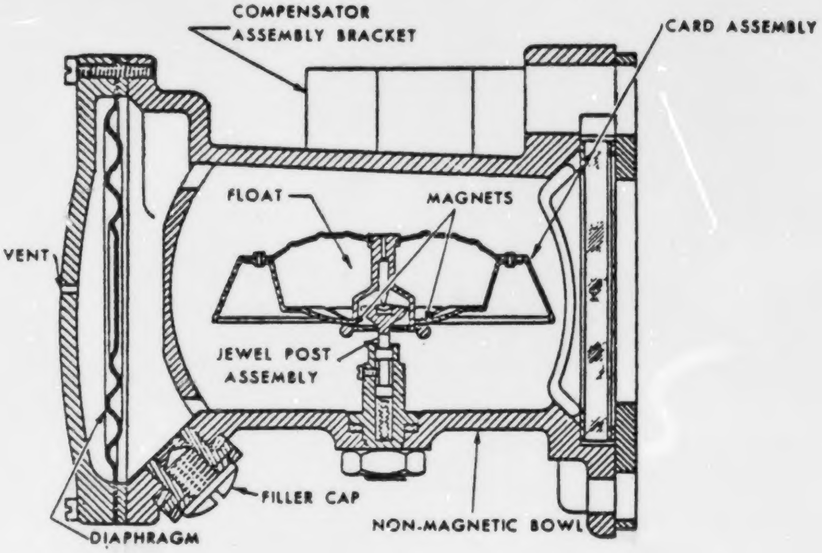
Answers to Frame 4: 1.

1637

Frame 6

A metal diaphragm at the rear of the compass bowl provides for expansion of the compass fluid due to temperature changes. This diaphragm is vented to cockpit pressure through a small air vent at the rear of the indicator. Some compasses incorporate a metal bellows which is also vented and operates in the same manner as the diaphragm.

Study the drawing below to determine how the diaphragm allows for expansion of the compass fluid.


COMPENSATOR ASSEMBLY BRACKET
CARD ASSEMBLY
FLOAT
MAGNETS
VENT
JEWEL POST ASSEMBLY
FILLER CAP
NON-MAGNETIC BOWL
DIAPHRAGM

Indicate the correct answer by placing a circle around the number preceding the answer you select.

The purpose of the diaphragm at the back of the indicator case is to

1. allow for changes in aircraft altitude.
2. allow for changes in variation.
3. allow for expansion and contraction of the fluid due to temperature changes.
4. prevent excessive movement of the fluid due to acceleration forces.

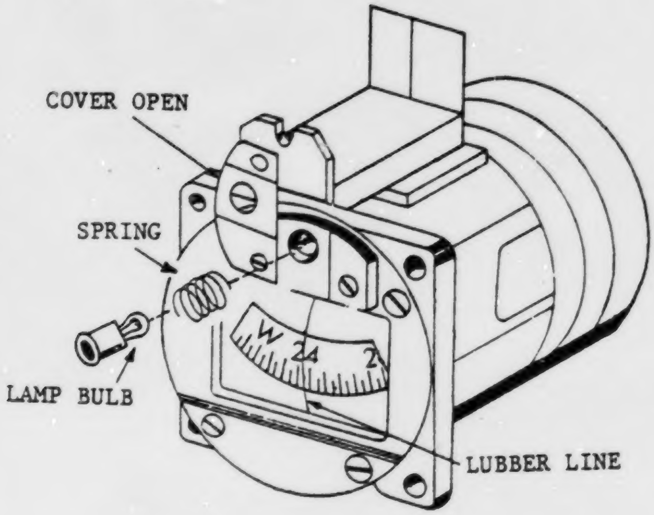
Answers to Frame 5: 1, 3, 4.

Frame 7

A luminous bar called a lubber line is attached to the case, and is visible through the cover glass. This lubber line is the reference from which the compass card is read.

An individual lighting system is generally provided in compasses for illuminating the indicator card when required.

Look at the picture below to determine the location of the lubber line and the light bulb.



Indicate the correct answer by placing a circle around the number preceding the answer you select.

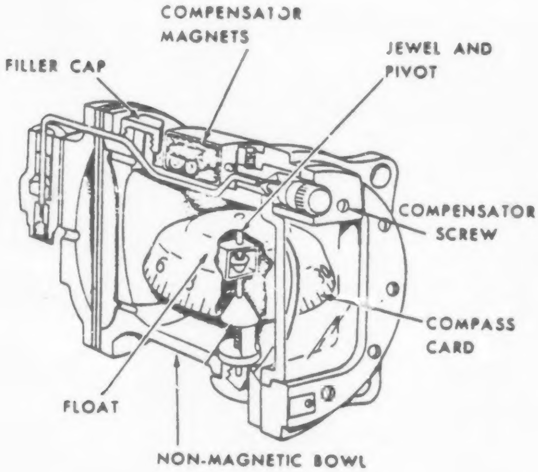
The lubber line is

1. a stationary reference line used to read the compass card.
2. a moveable reference line used to read the compass card.
3. an imaginary line used to read the compass card.

Answers to Frame 6: 3.

Frame 8

The standby compass is provided with a deviation compensator. Refer to the illustration below. The deviation compensator consists of four small permanent magnets. These magnets are turned by two screws labeled N-S and E-W. The function of this compensator is to adjust for errors in the compass readings.


COMPENSATOR MAGNETS
JEWEL AND PIVOT
FILLER CAP
COMPENSATOR SCREW
COMPASS CARD
FLOAT
NON-MAGNETIC BOWL

Circle the number preceding the true statements below.

1. Changes in temperature are compensated by the compasses deviation compensator.
2. The compensator magnets are turned by the N-S and E-W screws.
3. The deviation compensator adjusts for errors in the compass readings.

Answers to Frame 7: 1.

Errors in the compass reading are caused by magnetic fields produced by electrical wiring and the metal structure of the aircraft. The difference between the actual magnetic heading of the aircraft and the indication read on the compass card is called DEVIATION.

Circle the number preceding the true statements below.

1. Deviation is the difference between the actual heading and the compass reading.
2. The earth's magnetic field causes compass deviation.
3. Errors in the compass reading are caused by aircraft electrical wiring and metal structure.

Answers to Frame 8: 2, 3.

Frame 10

Frame 10 is a subterminal frame. If you miss any of the questions in this frame, review the appropriate frame before continuing with the package.

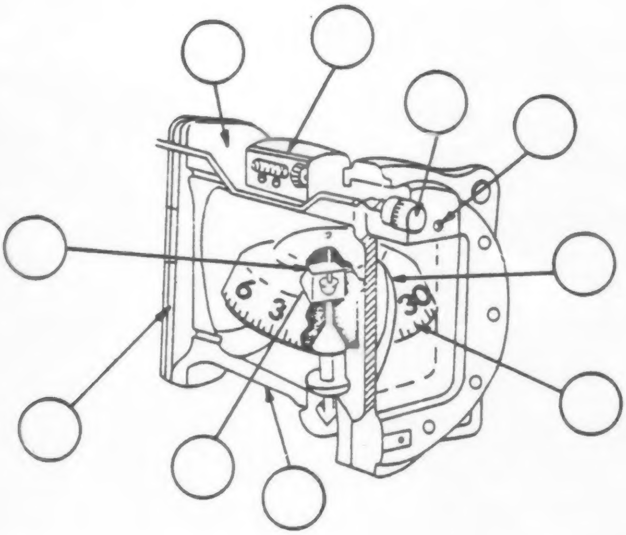
A. Circle the number preceding the true statements below.

1. Bar magnets in a magnetic compass align with the earth's longitudinal lines.
2. The magnetic compass is most accurate at the poles.
3. A free swinging compass will align with the earth's magnetic field.
4. The magnetic compass is not accurate at the poles because, in this area, the earth's magnetic field dips into the earth.
5. The magnetic compass is most accurate below 70 degrees latitude.
6. The direction seeking element in the magnetic compass is an electromagnet.
7. The scale mounted on the float assembly is graduated in five degree increments from zero (0) to 360 degrees.
8. The float assembly is mounted on a jewel and pivot.
9. Float oscillation is dampened by water inside the compass case.
10. Highly refined kerosene provides lubrication for the jewel and pivot.
11. A jewel and pivot provide a mounting for the float assembly.
12. The diaphragm at the rear of the compass compensates for changes in aircraft altitude.
13. Heading indications are read at the stationary reference called a lubber line.
14. A deviation compensator is provided on the compass to compensate for temperature changes.
15. The N-S and E-W screws are used to compensate for the effects of aircraft structure and electrical wiring.

Answers to Frame 9: 1, 3.

1642

B. Match the functions in the list to the components by placing the correct number in the circle on the illustration.



1. Allows the float to turn freely.
2. Corrects for deviation.
3. Allows for expansion of fluid.
4. Graduated in 5 degree increments.
5. The reference line used to read the compass card.
6. Nonmagnetic material to hold fluid.
7. Place to put fluid in.
8. Adjustment for compensating magnets.
9. Illuminates the compass.
10. Two north seeking magnets are attached to it.

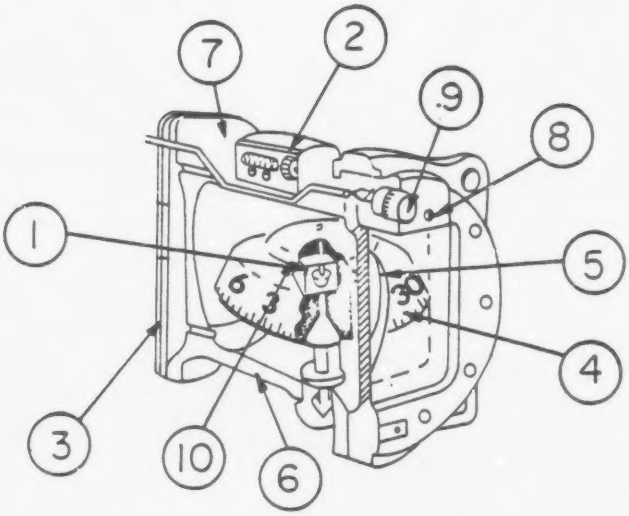
1715

1643

Answers to Frame 10:

Part A: 3, 4, 5, 7, 8, 10, 11, 13, 15.

Part B:


7
2
9
8
1
5
4
3
10
6

1716

Frame 11

In the previous frames (1-10) you learned the construction and operation of the pilot's standby compass. You also learned that deviation was caused by metal parts of the aircraft and electrical wiring, and that a compensator is provided on the compass for adjusting for these errors. In order to perform a compass calibration (adjustment of deviation errors) a compass swing is necessary. Compass swings can be accomplished on the ground or in the air. You will be concerned with only the Sight Compass Ground Swing method.

A compass correction card is used during a compass swing for recording aircraft compass readings, deviation errors, and aircraft magnetic headings. Using this card, deviation errors and corrections can be determined. As you learn the compass swing procedures, you will also become familiar with the Compass Correction Card. A compass correction card is shown below.

No Response Required

	COMPENSATING SWING			RESIDUAL SWING	
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N	ACTUAL HEAD (M)	AIRCRAFT COMP
N 000	004	000			
E 090	088	090			
S 180	184	180			
W 270	266	270			
	(1)	(2)	(1)-(2)	(3)	(4)

IF SWINGING COMPASS USED AHEAD OF AIRCRAFT, ADD OR SUBTRACT 180 DEGREES

Coeff $C = \frac{N-S}{2} = \frac{(\ )-(\ )}{2} =$

Coeff $B = \frac{E-W}{2} = \frac{(\ )-(\ )}{2} =$

Coeff $A = \frac{N+E+S+W}{4} = \frac{(\quad)+(\quad)+(\quad)+(\quad)}{4} =$

COMPASS			
SWUNG		BY	
TO FLY	STEER	TO FLY	STEER
N		180	
15		195	
30		210	
45		225	
60		240	
75		255	
90		270	
105		285	
120		300	
135		315	
150		330	
165		345	

Frame 12

Prior to performing a compass swing, a visual and an operational check will be accomplished to determine the serviceability of the compass. A visual inspection consists of inspecting the compass for a cracked cover glass or case. Also check for air bubbles in the fluid inside the case, this would be evidence of leakage. The fluid must be clear. If it is milky there is water in the fluid. Check for deterioration of the numbers on the compass card. Check the mounting screws. They should be tight and made of nonmagnetic material.

Circle the number of the true statements below.

1. The cover glass and case are checked for cracks during a visual inspection.
2. Steel screws may be used to mount the compass.
3. Water in the compass fluid will cause it to be cloudy or milky.
4. Deterioration of the card numbers should be checked during the visual inspection.

An operational check consists of two items:

1. Check the operation of the light to insure that it illuminates the compass card.

2. Use a piece of metal or a magnet to deflect the compass card in both directions.

As the float turns, watch for smooth movement of the float and check that the card returns to its original heading. If the float hangs up or does not return to its original heading, the compass must be replaced.

Circle the number preceding each true statement below.

1. An operational check consists of checking only the illumination of the compass card.

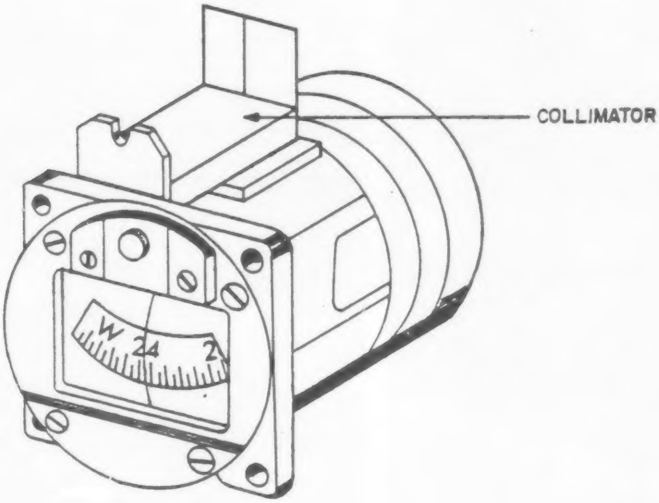
2. During an operational check, security of mounting should be checked.

3. The compass must be replaced if the card does not return to its original heading.

Answers to Frame 12: 1, 3, 4.

Frame 14

Frame 11 stated that this text will cover the "sight compass" method of performing a compass swing. A sight compass is a standby compass with the deviation compensator removed, and a collimator lens installed on the top of the compass. The collimator is a sighting device which enables a person to accurately sight down the centerline of the aircraft. This is done, during the compass swing, to determine the actual magnetic heading of the aircraft.



Circle the number preceding each true statement below.

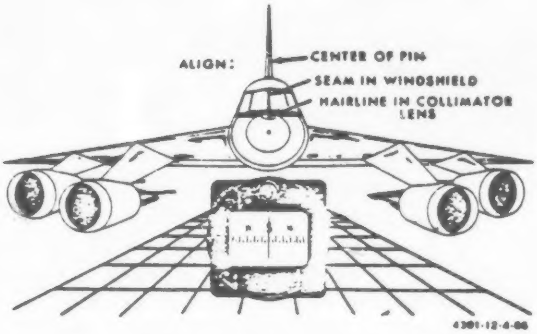
1. This text will cover the "in-flight" method of performing a compass swing.
2. A standby compass with the deviation compensator removed and a collimator installed on it is called a sight compass.
3. A sight compass is used to determine the indication of the standby compass in the aircraft.
4. The collimator is installed on the sight compass to enable taking accurate readings of the actual aircraft magnetic heading.

Answers to Frame 13. 3.

Frame 15

Refer to the illustration below. A sighting is being made to determine the actual magnetic heading of the aircraft. Standing in front of the aircraft, the sight compass is aligned on the centerline of the aircraft. Notice that the sight compass is indicating south (180 degrees). Therefore, 180 degrees must be added or subtracted from the sight compass indication to obtain the actual aircraft heading of north (000 degrees).

Some sight compasses have had the compass card turned around on the float, so that when you stand in fromt of the aircraft you will read the same heading as the aircraft's compass. If the sight compass has had its compass card reversed, it will be painted red.



Circle the number of the true statements below.

1. A compass that has had the deviation compensator removed and a collimator lens installed is called a sight compass.
2. If the floating compass card's position has been reversed the compass will be painted black.
3. A sight compass that is painted red does not have to have 180 degrees added or subtracted to or from its indication.

Answers to Frame 14: 2, 4.

Frame 16

Compass swings are performed in areas selected and prepared for this task. Swing sites must be large enough to taxi or tow the largest aircraft, to be swung, throughout 360 degrees. The site must be at least 600 feet from power lines that are above or below ground, and metal structures and buildings.

Circle the number preceding the true statements below.

1. The swing site must be large enough to allow the aircraft, being towed or taxied, to be turned to all cardinal headings (N, S, E, W).

2. Wiring below the ground will have no affect on the compass swing.

3. The swing site must be at least 1000 feet from any magnetic disturbances.

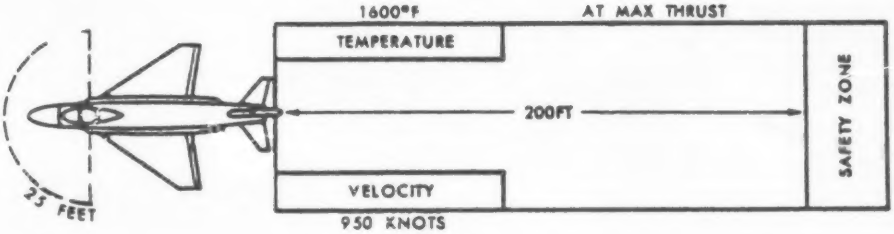
4. Buildings in or near the swing site may affect the results of a compass swing.

Answers to Frame 15: 1, 3.

1650

Because of the differences in the aircraft's magnetic field with the canopy up or down and with the engines running or not running, most aircraft are swung with the canopy down and the engine running. Because of this, safety is important when swinging a compass. On reciprocating engine aircraft, the propellers are dangerous. On jet aircraft, the engine intake suction is dangerous. The minimum safe distance in front of any aircraft is twenty-five (25) feet. The minimum safe distance behind any aircraft is two hundred (200) feet.

Study the drawing below to determine the danger areas around a jet aircraft.



Circle the number preceding the true statements below:

1. Compass swings are normally performed with the canopy up and no engines running.
2. The minimum safe distance in front of an aircraft is 50 feet.
3. The minimum safe distance behind an operating jet aircraft is 200 feet.

Answers to Frame 16: 1, 4.

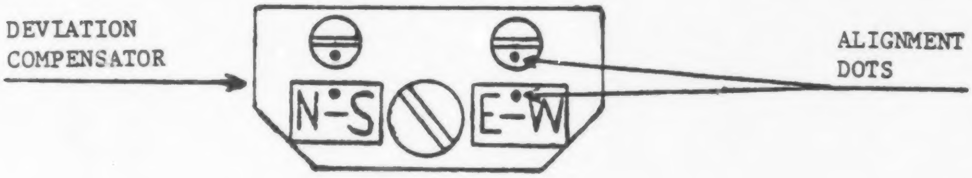
1723

1651

Frame 18

Preswing: Before beginning the compass swing, all moveable items that would affect the aircraft's magnetic field should be in the positions that they will occupy during flight. Personnel engaged in compensating the compass must remove all metal items from their person.

Using a nonmagnetic screwdriver, null the aircraft compass deviation compensator. This is done by aligning the dots on the adjustment screws with the dots on the compensator front plate. Below is an example of a deviation compensator with the dots in alignment.



Circle the number preceding the true statements below:

1. A proper swing is accomplished with all items in their inflight conditions and positions.

2. Watches and rings need not be removed when compensating the standby compass.

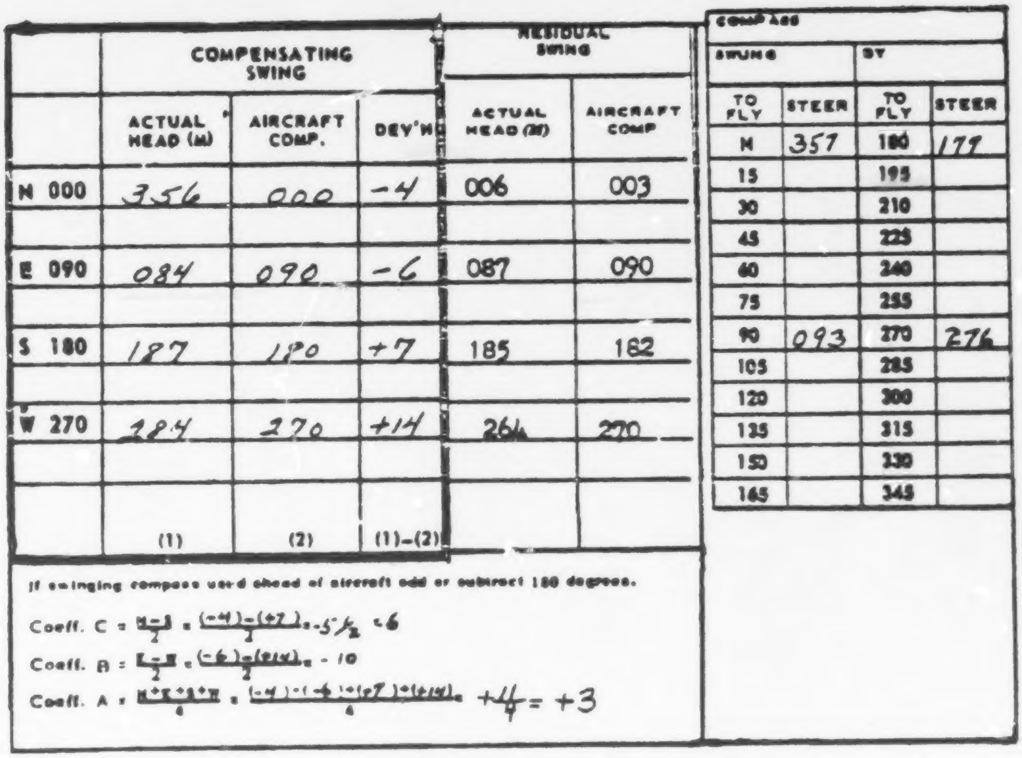
3. Any materials which could affect the compass indications must be removed from the persons conducting the swing.

4. Compensator nulling is accomplished by turning the adjustment screw dots away from the dots on the compensator front plate.

Answers to Frame 17: 3.

1724

Compass Swing: The actual compass swing consists of four parts or steps. During each of the steps, the four sections of the compass correction card will be completed. The first step in performing a compass swing is to determine how much error exists in the compass indications at the four cardinal headings (N, S, E, W). The COMPENSATING SWING section of the compass correction card is used to record the aircraft's actual heading and the standby compass indication. The difference between the actual heading and the compass indication is the deviation and is entered in the DEV'N column as a plus (+) or minus (-) value. Refer to the illustration below. The compensating swing section is outlined in heavy black.



	COMPENSATING SWING			RESIDUAL SWING	
	ACTUAL HEAD (M)	AIRCRAFT COMP.	DEV'N	ACTUAL HEAD (M)	AIRCRAFT COMP
N 000	356	000	-4	006	003
E 090	084	090	-6	087	090
S 180	187	180	+7	185	182
W 270	284	270	+14	264	270
	(1)	(2)	(1)-(2)		

If swinging compass used ahead of aircraft add or subtract 180 degrees.

Coeff. C = $\frac{N-S}{2} = \frac{(-4)-(+7)}{2} = -5\frac{1}{2} = -6$

Coeff. B = $\frac{E-W}{2} = \frac{(-6)-(+14)}{2} = -10$

Coeff. A = $\frac{N+E+S+W}{4} = \frac{(-4)+(-6)+(+7)+(+14)}{4} = +\frac{11}{4} = +3$

COMPASS			
SWUNG		BY	
TO FLY	STEER	TO FLY	STEER
N	357	180	177
15		195	
30		210	
45		225	
60		240	
75		255	
90	093	270	276
105		285	
120		300	
135		315	
150		330	
165		345	

Circle the number preceding the true statements below.

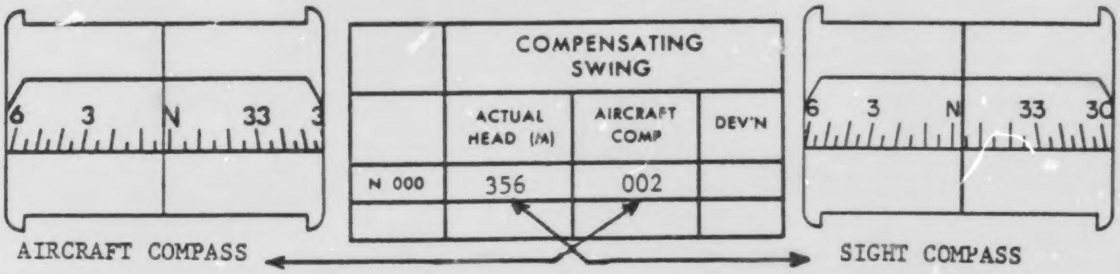
1. The purpose of the compensating swing is to determine the amount of error that is in the sight compass.
2. Values determined during the swing are recorded on the correction card.
3. Deviation errors are determined during the compensation swing.
4. Deviation errors will be recorded on the compass correction card as fractions.

Answers to Frame 18: 1, 3.

1653

Frame 20

When performing the compensation swing, have the aircraft turned, using the standby compass reading, to within 3 degrees of the desired heading. Allow sufficient time for the float to settle before recording the compass indication on the compass correction card. This indication is recorded in the AIRCRAFT COMP column (opposite N, the first heading of the aircraft). Then using the sight compass, determine the actual aircraft heading. This is done by standing at least 50 feet in front of the aircraft and sighting down the longitudinal axis. Read the magnetic heading from the sight compass. This reading will be the actual aircraft heading, and is recorded in the ACTUAL HEADING (M) column of the compass correction card. Refer to the illustration below, read each compass and note where their readings are recorded on the compass correction card.



Complete the following statements by underlining the correct response.

1. The (sight compass, aircraft standby compass) is used as the reference for aligning the aircraft to the desired heading.

2. When performing the compensation swing, the aircraft will be headed to within (2, 3, 4, 5) degrees of the desired heading.

3. In the illustration above, the actual aircraft magnetic heading is (356 degrees, 357 degrees, 359 degrees).

4. In the illustration above, the standby compass indication is (356 degrees, 000 degrees, 002 degrees).

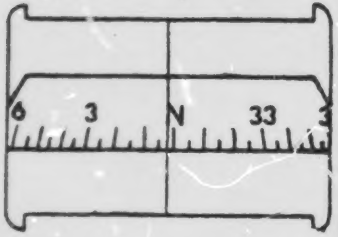
5. Sightings should be taken at least (25, 50) feet from the aircraft.

Answers to Frame 19: 2, 3.

1726

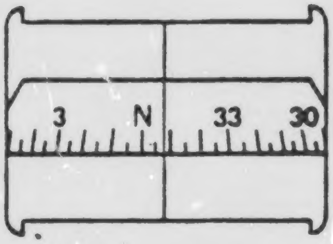
Frame 21

To determine the plus (+) or minus (-) value to be entered in the DEV'N column of the compass correction card, compare the actual heading and the aircraft compass readings that are entered on the form. If the actual heading is less than the aircraft compass indication the deviation (DEV'N) will be minus (-). Refer to the illustration below.



AIRCRAFT COMPASS

	COMPENSATING SWING		
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000	352	002	-10



SIGHT COMPASS

With the information given below each illustration, fill in the ACTUAL HEAD (M), AIRCRAFT COMP, and DEV'N columns.

1.

	COMPENSATING SWING		
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000			

ACTUAL HEAD (M) 002
AIRCRAFT COMP 000

2.

	COMPENSATING SWING		
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000			

ACTUAL HEAD (M) 358
AIRCRAFT COMP 003

3.

	COMPENSATING SWING		
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000			

ACTUAL HEAD (M) 002
AIRCRAFT COMP 002

4.

	COMPENSATING SWING		
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000			

ACTUAL HEAD (M) 002
AIRCRAFT COMP 357

Answers to Frame 20:

1. aircraft standby compass; 2. 3; 3. 356 degrees;
4. 002 degrees; 5. 50 feet.

Frame 22

To complete the remaining portion of the compensation swing, have the aircraft headed to east, and repeat the procedures outlined in Frames 20 and 21. The appropriate values for the east heading will be entered in the columns opposite the E 090. Determine the DEV'N values to be entered in the DEV'N column. When the entries are complete, have the aircraft moved to the south heading. Repeat the procedures and make the entries for this heading as you did for the north and east headings. Finish the compensation swing by having the aircraft headed west and repeat the above procedures. Recall that as the aircraft is moved to each heading, it must be positioned within 3 degress of the heading as shown on the aircraft's standby compass. Also, allow sufficient time for the compass card to stabilize at each heading before the indications are entered in the AIRCRAFT COMP column of the compass correction card.

Determine the deviation for each cardinal heading and compass indication given in the illustration below. Enter the DEV'N in the proper column on the correction card.

	COMPENSATING SWING		
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000	356	358	
E 090	084	093	
S 180	187	183	
W 270	272	270	

Answers to Frame 21:

1.

	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000	002	000	+2

2.

	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000	358	003	-5

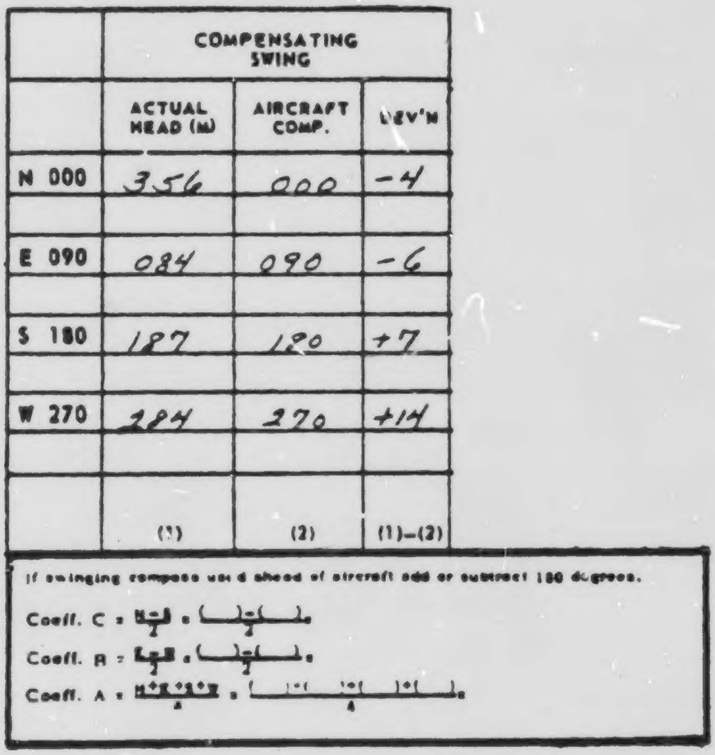
3.

	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000	002	002	0

4.

	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N
N 000	002	357	+5

The next step in the swing procedures is to determine how much calibration (adjusting the aircraft compass) must be performed. The amount of calibration is determined by using the formulas on the compass correction card. Refer to the illustration below. The formulas are outlined in heavy black. The formula labeled coefficient A $\frac{(N+E+S+W)}{4}$ is used to determine how much adjustment is necessary for correcting installation error. Installation error is caused by the improper installation of the aircraft compass in its mounting. The compass must be mounted exactly on the aircraft longitudinal axis.



	COMPENSATING SWING		
	ACTUAL HEAD (M)	AIRCRAFT COMP.	DEV'N
N 000	356	000	−4
E 090	084	090	−6
S 180	187	180	+7
W 270	284	270	+14
	(1)	(2)	(1)−(2)

If swinging compass used ahead of aircraft add or subtract 180 degrees.

Coeff. C = $\frac{N-S}{2} = \frac{(\quad)-(\quad)}{2}$.

Coeff. B = $\frac{E-W}{2} = \frac{(\quad)-(\quad)}{2}$.

Coeff. A = $\frac{N+E+S+W}{4} = \frac{(\quad)+(\quad)+(\quad)+(\quad)}{4}$.

Using the DEV'N values in the illustration above, we will compute Coef A to determine how much correction is needed for installation error.

$$\frac{N + E + S + W}{4} = \text{Avg installation error}$$

$$\frac{(-4)+(-6)+(+7)+(+14)}{4} =$$

$$\frac{(-10)+(+21)}{4} = \frac{+11}{4} = +2\ 3/4 = 3$$

Frame 23 Continued

By algebraically adding the deviation and dividing by four, it was determined that the amount of correction is +3.

Using the figures given in the formula below, compute the installation error (Coeff. A) for each problem.

1. $$\frac{(-9) + (+9) + (-5) + (-10)}{4} =$$

2. $$\frac{(+2) + (-11) + (+3) + (+10)}{4} =$$

3. $$\frac{(+2) + (-4) + (-3) + (+6)}{4} =$$

Answers to Frame 22:

N 000 -2; E 090 -9; S 180 +4; W 270 +2.

Frame 24

Coefficients B and C are the formulas for determining the amount of correction that must be made on the N-S and E-W adjusting screws located on the compensator. Adjusting these screws compensates for errors in the compass caused by aircraft metal structures, motors, generators, etc. This is deviation error. When computing the formulas for deviation errors, change the sign of the subtrahend and add.

Examples: Coef. C $\frac{N-S}{2} = \frac{(-4) - (+7)}{2} = \frac{(-4) + (-7)}{2} = \frac{-11}{2} = -5\ 1/2 = -6$

Subtrahend

Coef. B $\frac{E - W}{2} = \frac{(-6) - (+14)}{2} = \frac{(-6) + (-14)}{2} = \frac{-20}{2} = -10$

Using the figures given in the problems below, compute the corrections for each problem.

1. $\frac{N-S}{2} = \frac{(-9) - (-5)}{2} =$
2. $\frac{N-S}{2} = \frac{(+2) - (+3)}{2} =$
3. $\frac{N-S}{2} = \frac{(+2) - (-3)}{2} =$
4. $\frac{N-S}{2} = \frac{(-8) - (-8)}{2} =$
5. $\frac{E-W}{2} = \frac{(+9) - (-10)}{2} =$
6. $\frac{E-W}{2} \quad \frac{(-11) - (+10)}{2} =$
7. $\frac{E-W}{2} = \frac{(-4) - (+6)}{2} =$
8. $\frac{E-W}{2} = \frac{(+8) - (+8)}{2} =$

Answers to Frame 23:

1. $\frac{(-24) + (+9)}{4} = \frac{-15}{4} = -3\ 3/4 = -4$
2. $\frac{(+15) + (-11)}{4} = \frac{+4}{4} = +1$
3. $\frac{(+8) + (-7)}{4} = \frac{+1}{4} = 0\ 1/4 = 0$

1659

Frame 25

After Coefficients A, B, and C have been computed and the amount of aircraft compass error has been determined, the actual calibration of the compass must be performed. Coefficient A (Installation error) will first be compensated for. To adjust for installation error, have the aircraft headed north by the aircraft compass indication. Using nonmagnetic shims (washers) remount the compass so that the proper amount of correction has been added or subtracted to the compass indication. Example +3 installation error, with the aircraft headed north (000) remount the compass so that it indicates 003 degrees. By doing this you will have remounted the compass on the aircraft longitudinal axis.

Circle the number preceding each true statement below.

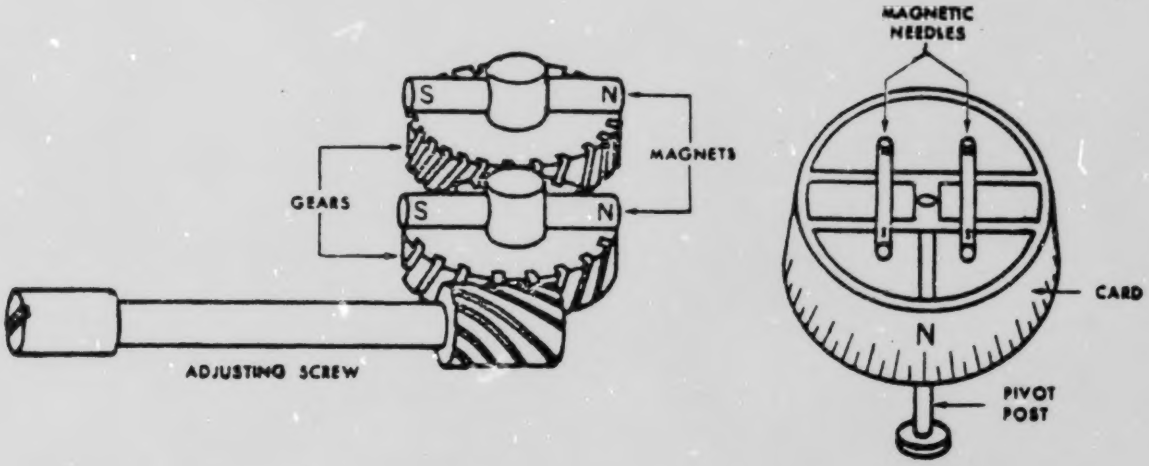
1. Magnetic shims are used to install the aircraft's standby compass.
2. Calibration of the compass is performed after coefficients are determined.
3. Coefficient A is the formula used to determine deviation error.
4. Coefficient A is compensated for by realigning the compass in its mount.
5. The compass must be mounted on the earth's longitudinal axis.

Answers to Frame 24:

1. $\frac{(-9) + (+5)}{2} = \frac{-4}{2} = -2$
2. $\frac{(+2) + (-3)}{2} = \frac{-1}{2} = -0\ 1/2 = -1$
3. $\frac{(+2) + (+3)}{2} = \frac{+5}{2} = +2\ 1/2 = +3$
4. $\frac{(-8) + (+8)}{2} = \frac{0}{2} = 0$
5. $\frac{+19}{2} = +9\ 1/2 = +10$
6. $\frac{-21}{2} = -10\ 1/2 = -11$
7. $\frac{-10}{2} = -5$
8. $\frac{0}{2} = 0$

1732

With installation error adjusted, coefficients B and C (deviation error) will be compensated for by adjusting the N-S and E-W adjustment screws on the compensator. The compensator consists of two adjustable sets of magnets mounted on small rotatable gears. Refer to the figure below. One set of magnets is for north-south, and one set is for east-west. Turning the screw moves the magnets to counterbalance the magnetic influence acting on the card magnets. The illustration shows how the magnets are rotated when the adjustment screw is turned.



Compensator.

Look at the drawing of the compass card (above right) with the magnetic needles (bar magnets) shown on the top of the card. Remember, the compass card continuously points to north while the case rotates around it. The compensator magnets are located close to the bar magnets and to the rear of the compass body. At north the compensator magnets affect the north seeking end of the bar magnets. If you rotate the compass body, the compensator magnets are now positioned close to the south end of the bar magnets. This means that an adjustment of the compensator magnets will affect the north indication and have an equal, but opposite, effect on the south indication. For this reason, you must use the algebraic formulas given to determine the corrections.

Study the drawings and visualize the position of the compensator magnets in relation to the magnetic needles (bar magnets) on the compass card.

No Response Required.

Answers to Frame 25: 2, 4.

Frame 27

Installation error was corrected with the aircraft headed north. Coefficient C (N-S) deviation will be compensated for with the aircraft on the same heading. Using a nonmagnetic screwdriver, adjust the N-S screw so that the correct amount of N-S deviation error is added or subtracted from the compass indication. Example: Coefficient C (the N-S deviation error) was computed to be -6. The aircraft is headed 003 by the aircraft standby compass, turn the N-S screw to subtract 6 degrees from the compass indication. The N-S adjustment screw will be turned until the standby compass indication is 357.

Circle the number preceding the true statements below.

1. The aircraft must be headed north to compensate for Coefficient A values.

2. Coefficient C is corrected by using both the N-S and E-W adjustment screws.

3. Coefficient C is adjusted on the N-S adjustment screw with the aircraft headed north.

4. Nonmagnetic screwdrivers are necessary for correcting deviation errors.

5. If the N-S deviation is +3 and the aircraft compass is indicating 000 degrees, the N-S screw would be turned so that the compass would indicate 357 degrees.

1734

Frame 28

Coefficient B (E-W) deviation is adjusted with the aircraft headed east (090 degrees). This adjustment is the same as the adjustment for Coefficient C (N-S deviation). Example: Coefficient B (E-W deviation error) was computed to +5. With the aircraft headed east (090 degrees) by the aircraft standby compass, turn the E-W screw to add 5 degrees to the compass indication. Adjust the E-W screw until the standby compass indication is 095 degrees.

Circle the number preceding the true statement below.

1. Coefficient B is adjusted with the aircraf headed north.
2. Coefficient B is adjusted on the E-W adjustment screw, with the aircraft headed east.
3. If the E-W deviation is -4 and the aircraft compass is indicating 090 degrees, the E-W screw would be turned so that the compass would indicate 086 degrees.

Answers to Frame 27: 1, 3, 4.

Frame 29

A residual swing is accomplished after corrections have been made on the compass. This portion of the swing is to determine how much error still remains in the compass readings after the corrections were made. The residual swing is similar to the compensating swing. The aircraft is headed to the four cardinal headings and the actual magnetic heading is read with the sight compass. The actual heading and the compass indication are entered in the appropriate columns of the residual swing section of the compass correction card. (Refer to the illustration below.) After the residual swing has been completed, these values will be used to complete the TO FLY--STEER section of the compass correction card.

	COMPENSATING SWING			RESIDUAL SWING	
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N	ACTUAL HEAD (M)	AIRCRAFT COMP
N 000				001	000
E 090				089	090
S 180				178	181
W 270				272	270

Circle the number preceding each true statement below.

1. A compensation swing is performed to determine the existing errors after compensation has been done.
2. Residual swings are accomplished prior to correcting for Coefficients A, B, and C.
3. Information obtained during the residual swing is used to complete the TO FLY--STEER card.

Answers to Frame 28: 2, 3.

Frame 30

The TO FLY--STEER card is the section of the compass correction card which is detached and placed in a holder located in the cockpit. The information on this card enables the pilot to steer his aircraft on a magnetic heading using a compass indication that is not completely accurate. The information recorded during the residual swing is used to tell the pilot how much error still remains in the compass indication after the compass has been calibrated. Below is an illustration of a TO FLY--STEER card, which indicates to the pilot that 1-degree error exists at NORTH, 1-degree error at EAST, 3-degrees error exists at SOUTH, and 2-degrees at WEST.

COMPASS			
SWUNG		BY	
TO FLY	STEER	TO FLY	STEER
N	359	180	183
15		195	
30		210	
45		225	
60		240	
75		255	
90	091	270	268
105		285	
120		300	
135		315	
150		330	
165		345	

Circle the number preceding each true statement below.

1. After completing the TO FLY--STEER card, it must be placed in the aircraft cockpit.

2. The TO FLY--STEER card enables the pilot to fly accurate headings using the indications from an inaccurate source.

Answers to Frame 29: 3.

Frame 31

Use the illustration below to determine how the information in the residual swing columns is used to complete the STEER column of the TO FLY--STEER card. Using north as an example, note that when the aircraft is headed 001 degrees the compass indicates 000 degrees. The indication is one degree less than the actual heading. Therefore, to fly a heading of 000 degrees, the pilot must steer by the compass one degree less than the actual heading, or an indicated heading of 359 degrees to fly 000 degrees. Study the figures below to determine how the TO FLY--STEER values for east, south, and west are determined.

RESIDUAL SWING	
ACTUAL HEAD (M)	AIRCRAFT COMP
001	000
089	090
178	180
272	270

COMPASS			
SWUNG		BY	
TO FLY	STEER	TO FLY	STEER
N	359	180	182
15		195	
30		210	
45		225	
60		240	
75		255	
90	091	270	268
105		285	
120		300	
135		315	
150		330	
165		345	

With the residual swing information given below, fill in the appropriate spaces in the TO FLY--STEER card.

RESIDUAL SWING	
ACTUAL HEAD (M)	AIRCRAFT COMP
002	000
092	090
183	180
268	270

COMPASS			
SWUNG		BY	
TO FLY	STEER	TO FLY	STEER
N		180	
15		195	
30		210	
45		225	
60		240	
75		255	
90		270	
105		285	
120		300	
135		315	
150		330	
165		345	

Answers to Frame 30: 1, 2.

1666.

Frame 32

Refer to the illustration in Frame 31 and notice that the aircraft compass indications are all exactly on the cardinal headings (000, 090, 180, and 270). In actual practice, these indications are seldom possible to achieve. When the aircraft is headed to the cardinal headings, it is necessary to wait for the compass card to settle to its stable (card not moving) indications. After the compass card stops moving, the indication should be within 3 degrees of the cardinal heading. If it is not, the aircraft must be moved so that the indication is within 3 degrees of the cardinal heading. After the compass indication has settled, the actual aircraft heading and the compass indication is recorded in the appropriate residual swing columns.

In the figure below, compute the coefficients A, B, and C from the compensating swing readings. Then fill in the pilot's correction card STEER column with the residual swing readings.

	COMPENSATING SWING			RESIDUAL SWING	
	ACTUAL HEAD (M)	AIRCRAFT COMP	DEV'N	ACTUAL HEAD (M)	AIRCRAFT COMP
N 000	004	000	+4	003	001
E 090	088	090	-2	090	090
S 180	184	180	+4	182	180
W 270	266	270	-4	269	270
	(1)	(2)	(1)-(2)	(3)	(4)

COMPASS			
SWUNG		BY	
TO FLY	STEER	TO FLY	STEER
N		180	
15		195	
30		210	
45		225	
60		240	
75		255	
90		270	
105		285	
120		300	
135		315	
150		330	
165		345	

IF SWINGING COMPASS USED AHEAD OF AIRCRAFT, ADD OR SUBTRACT 180 DEGREES

$$\text{Coeff C} = \frac{N-S}{2} = \frac{(\quad) - (\quad)}{2} =$$

$$\text{Coeff B} = \frac{E-W}{2} = \frac{(\quad) - (\quad)}{2} =$$

$$\text{Coeff A} = \frac{N+E+S+W}{4} = \frac{(\quad) + (\quad) + (\quad) + (\quad)}{4} =$$

Answers to Frame 31:

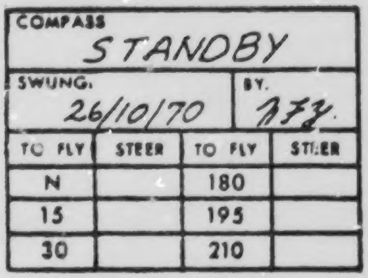
N	358	S	177
E	88	W	272

1739

1667

Frame 33

After completion of the compass swing and the TO FLY—STEER card, it is necessary to fill in the required data on the compass correction card. On the front side of the TO FLY—STEER card spaces are provided for the following information; type of compass, date that the compass swing was done, and the initials of the person who completed the entries on the card. Below is an example of the entries on the TO FLY—STEER card.



COMPASS
STANDBY

SWUNG.
26/10/70

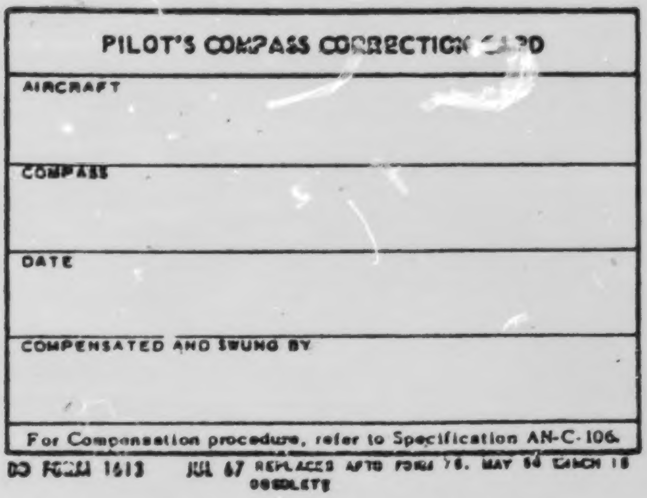
BY.
JFJ.

TO FLY	STEER	TO FLY	STEER
N		180	
15		195	
30		210	

The compass correction card containing the entries made during the compensation swing, computing the formulas, and residual swing must be filed in the shop until the next compass swing on that aircraft is accomplished. On the reverse side of this card spaces for the following entries are provided:

Aircraft: Aircraft serial number.
Compass: Type compass in the aircraft.
Date: Date the swing was accomplished.
Compensated and Swung by: Name of person performing the compass swing.

Below is an example of the reverse side of the pilot's correction card.



PILOT'S COMPASS CORRECTION CARD

AIRCRAFT

COMPASS

DATE

COMPENSATED AND SWUNG BY

For Compensation procedure, refer to Specification AN-C-106.

DD FORM 1613 JUL 67 REPLACES AFTO FORM 76, MAY 54 WHICH IS OBSOLETE

Compensated and
Swung by

[illegible] from DD Form 1613

1740

The answers to Frame 32 are:

1. Coeff. A is +1
2. Coeff. B is +1
3. Coeff. C is 0
4. Compute the STEER headings.

N	358
90	90
180	178
270	271

After completion of this programmed text, go to the appraisal room and take the appraisal on the material covered in this text.

1669

3ABR32531-WB-402 (401)
3ABR32632B-WB-501
7 March 1979

Instrument/Flight Control Branch
Chanute AFB, Illinois

INSPECT, SWING AND COMPLETE PILOT'S CARD, MAGNETIC (STANDBY) COMPASS

OBJECTIVES

Given a workbook and compass trainer, perform an inspection and operational check with a minimum of 100% accurate workbook responses.

Given a workbook, sight compass and compass trainer, swing and make compensation adjustments with a minimum of 80% accurate workbook responses.

Given a workbook and compass trainer, accomplish the pilot's correction card with a minimum of 80% accurate workbook responses.

INSTRUCTIONS

This workbook will be used in conjunction with programmed text 3ABR32531-PT-401 (3ABR32632B-PT-501), OPERATION OF MAGNETIC (STANDBY) COMPASS.

READ ALL STEPS BEFORE STARTING PERFORMANCE. Complete the workbook by performing each step as outlined in the workbook, and by making the appropriate responses as required by the workbook. Your instructor will observe your performance during the swing for correct procedure and will check your computations for accuracy upon completion of the workbook. If there is any portion of the workbook that you do not understand, ask your instructor BEFORE you attempt to perform that step.

EQUIPMENT

	Basis of Issue
Direct Reading Compass Trainer	1/student
Sight Compass (B-16 or B-21)	1/student
Nonmagnetic Screwdriver	1/student

PROCEDURE

Your instructor will observe your performance during the swing for correct procedure and will check your computations for accuracy upon completion of the workbook. READ ALL STEPS BEFORE STARTING PERFORMANCE.

Caution: Remove jewelry and all magnetic materials from your person.

Supersedes 3ABR32531-WB-401, 3ABR32532B-WB-501, 2 June 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 250; TTVSA - 1

Designed for ATC Course Use. Do Not Use on the Job.

1742

1. Inspection. Perform a visual inspection of the compass on the trainer, and check for the following:

a. Evidence of leakage (air bubbles).

Results of Check	
S	U

b. Security of mounting (screws tight and of a nonmagnetic material).

Results of Check	
S	U

c. Float for deterioration (numbers on card legible).

Results of Check	
S	U

d. Fluid for color (milky).

Results of Check	
S	U

e. Cover glass (chipped glass, cracks).

Results of Check	
S	U

2. Swing and compensate the compass and complete the Pilot's Correction Card.

Note: Remove the Pilot's Correction Card from the back of this workbook. Use the correction card to make appropriate entries as directed in the procedures below.

a. Compensation Swing.

(1) Null the compensator.

(2) Align the trainer to the cardinal headings and record the actual heading and aircraft compass indications in the appropriate spaces on the Pilot's Correction Card provided.

(3) Determine the deviation errors for each heading and record these in the appropriate spaces on the correction card.

b. Compensation.

(1) Using the values obtained during the compensation swing and using the formulas on the Pilot's Correction Card, compute the amount of correction for coefficients A, B and C.

(2) Using the tools provided, make the necessary adjustments on the compass.

c. Residual Swing.

(1) Align the trainer to the cardinal headings and record the actual headings and compass indications in the appropriate spaces on the Pilot's Compass Correction Card.

(2) Using the values obtained during the residual swing, enter the appropriate STEER values for each cardinal heading in the appropriate spaces on the Pilot's Compass Correction Card.

1671

	COMPENSATING SWING			RESIDUAL SWING	
	ACTUAL HEAD (*M*)	AIRCRAFT COMP	DEV'N	ACTUAL HEAD (*M*)	AIRCRAFT COMP
N 000					
E 090					
S 180					
W 270					
	(1)	(2)	(1) - (2)	(3)	(4)

COMPASS

SWUNG BY

TO FLY	STEER	TO FLY	STEER
N		180	
15		195	
30		210	
45		225	
60		240	
75		255	
90		270	
105		285	
120		300	
135		315	
150		330	
165		345	

IF SWINGING COMPASS USED AHEAD OF AIRCRAFT, ADD OR SUBTRACT 180 DEGREES

Coeff $C = \frac{N-S}{2} = \frac{(\quad)-(\quad)}{2} =$

Coeff $B = \frac{E-W}{2} = \frac{(\quad)-(\quad)}{2} =$

Coeff $A = \frac{N+E+S+W}{4} = \frac{(\quad)+(\quad)+(\quad)+(\quad)}{4} =$

* GPO : 1968 O—299-125

PILOT'S COMPASS CORRECTION CARD

AIRCRAFT

COMPASS

DATE

COMPENSATED AND SWUNG BY

For Compensation procedure, refer to Specification AN-C-106.

Compensated and Swung by ______________________

Detached from DD Form 1613

DD FORM 1613 JUL 67 REPLACES AFTO FORM 76, MAY 50 WHICH IS OBSOLETE

INSTRUCTOR'S SIGNATURE FOR SATISFACTORY COMPLETION ______________________

1744 3

1672

PROGRAMMED TEXT
3ABR32531-PT-403
3ABR32632B-PT-502B

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

Attitude Heading Reference and Gyro Stabilized Magnetic Compass Systems

7 February 1978

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Chanute Air Force Base, Illinois

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FOREWORD

This programmed text was prepared for use in the 3ABR32531, Avionics Instrument Systems Specialist Course and the 3ABR32632B, Integrated Avionic Systems Specialist Course. The material herein has been validated by 21 students from the respective courses. At least 90% of the students from the courses achieved the objective as stated. The average time for completion is 5 hours and 45 minutes.

OBJECTIVE

1. Without references, identify facts pertaining to the purpose, operation, and/or characteristics of attitude reference systems with a minimum accuracy of 70%.

   a. Attitude Heading Reference Systems.

   b. Compass Systems (Gyro Stabilized).

INSTRUCTIONS

This programmed text presents information in small steps called frames. Each frame is followed by some form of questioning. Immediately after reading each frame, you will make the required response. Check your answers each time with the correct answer shown at the end of the following frame. If you make the correct response, go on to the next frame. If you make an incorrect response, reread the frame before going on to the next frame. Be sure that you understand the material in each frame before continuing.

SPECIAL INSTRUCTIONS

This text covers the entire auxiliary flight reference system. You will learn about one section at a time. You will be tested after each section to determine if you have acquired the necessary understanding of that portion. You must understand each section before continuing to the next. If you do not understand the text, or have a question, raise your hand and your instructor will help you before continuing.

Handout 3ABR32531-HO-403 is provided to be used with this programmed text. Pages 3-10 of the HO will be used with section A of the text, pages 11 and 12 will be used with section B, and page 13-20 will be used with section C. Handout 3ABR32531-HO-403A will also be used with this programmed text.

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1674

SECTION A - ATTITUDE REFERENCE SYSTEM

Part I - General Description of the Attitude Reference System

1747

Frame 1

The Auxiliary Flight Reference System (AFRS) is a standby or backup system to the Inertial Bomb Navigation System (IBNS). The Inertial Bomb Navigation System (IBNS) is a complex system that is a separate career field of its own. Since some of the functions of the IBNS and our system (Auxiliary Flight Reference System) overlap, it will be necessary to refer to the IBNS from time to time.

NO RESPONSE REQUIRED

Frame 2

The Auxiliary Flight Reference System (AFRS) produces attitude and heading signals. These signals are applied to indicators in the cockpit. Major components of the Auxiliary Flight Reference System (AFRS) are the Displacement Gyro Package, Compass System Controller, Remote Compass Transmitter, and Electronic Control Amplifier. Page 3 of HO-403 shows the components and subcomponents of the AFRS. Study the illustration to become familiar with the major components.

Write the names of the major AFRS components in the spaces provided below.

1. ______________________________.

2. ______________________________.

3. ______________________________.

4. ______________________________.

The Auxiliary Flight Reference System is actually two systems integrated into one. These are the Gyro Stabilized Magnetic Compass System and the Attitude Reference System. We will cover each system separately. The first to be discussed is the "Attitude Reference System." The major components of the "Attitude Reference System" are the Displacement Gyro and the Electronic Control Amplifier (ECA). (Refer to page 4 of HO-403.) Pitch and roll signals produced by the Displacement Gyro are transmitted to the ECA to be amplified. The amplified pitch and roll outputs from the ECA are transmitted to the Standby Attitude Indicator (SAI). In the event of an IBNS malfunction, these signals will also be transmitted to the Attitude Director Indicator (ADI). We will also cover the Flight Instrument Reference Switch (Prim-Aux Switch), Instrument Set Coupler (ISC), and various control relays. These subcomponents, like the SAI and ADI are not part of the AFRS, but are necessary for system operation.

Study the diagram, page 4, HO-403 to become familiar with the components and subcomponents used in the operation of the AFRS. The arrows show signal flow to components and indicators.

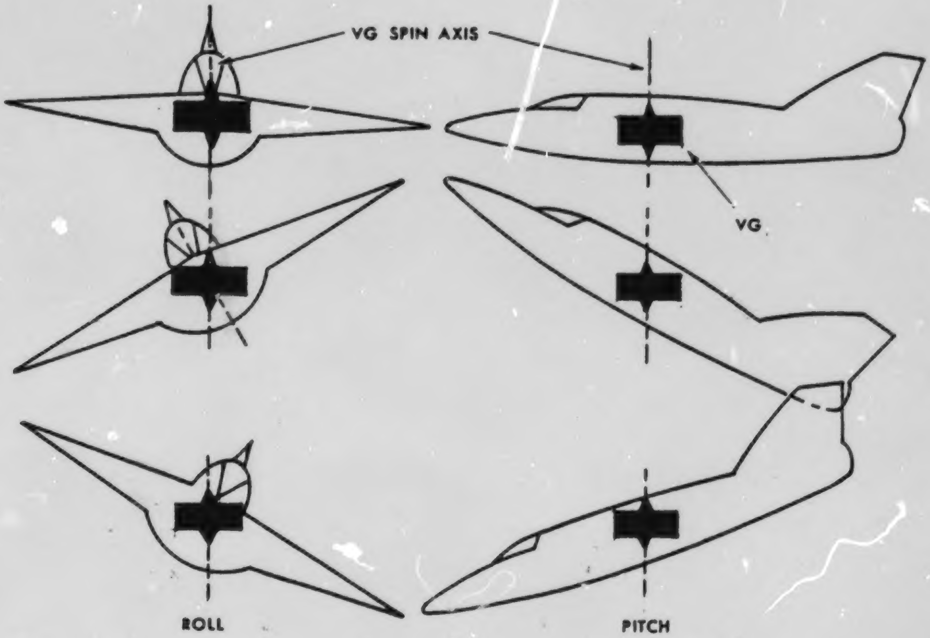
Match the component or subcomponent in Column II to the statement/function in Column I. You may refer to the diagram on page 4 of HO-403.

		I		II
_____, _____	1.	Are major Attitude Reference System components.	a.	Attitude Director Indicator
_____, _____, ____ _____, _____	2.	Are not part of the Attitude System, but are necessary for proper operation.	b.	Standby Attitude Indicator
			c.	Control relay
_____	3.	Receives and amplifies pitch and roll signals.	d.	Electronic Control Amplifier
____	4.	Receives input signals directly from the ECA to provide attitude indications.	e.	Displacement Gyro
			f.	Prim-Aux Switch
			g.	Instrument Set Coupler

Answers to Frame 2:
1. Displacement Gyro Package
2. Compass System Controller
3. Remote Compass Transmitter
4. Electronic Control Amplifier

Frame 4

The first component to be covered is the Displacement Gyroscope Platform (Displacement Gyro). It contains two gyros; a directional gyro which produces heading reference signals, and a vertical gyro which produces pitch and roll signals. The directional gyro output signal is not used by the attitude portion of the AFRS, therefore its operation will be covered at a later time. The vertical gyro (VG) is universally mounted with its spin axis maintained perpendicular to the earth. With its spin axis perpendicular, the VG produces attitude signa (pitch and roll); attitude being the position of the aircraft in relatio ship to the earth's horizon.



Using the above illustration, study the relationship between the aircraft and the vertical gyro and underline the correct answer.

1. The vertical gyro references the (attitude, heading) of the aircraft in pitch and roll.

2. The vertical gyro must be (semiuniversally, universally) mounted to remain rigid during aircraft maneuvers.

3. The vertical gyro has a (horizontal, vertical) spin axis.

Answers to Frame 3: d e 1. a b c f g 2. d 3. b 4.

So far, you know that the gyro platform (displacement gyro) contains the vertical gyro (VG). The VG holds a fixed position due to rigidity. This allows the gimbals to move about the gyro (VG) without changing the VG's position. Now we must produce pitch and roll output signals which will be used to indicate the degree of movement about the gyro. This is done by placing synchrotransmitters between the gyro gimbals. Refer to page 5, HO-403. Note the location of the pitch and roll transmitters (CXs) in figure A. Figure B shows the relationship between the gyro and gimbals with the aircraft having a nose-up attitude causing a change in the pitch synchro output. Figure C shows the gimbal relationship during aircraft roll attitudes, causing a change in the roll synchro output. Attitude signals are sent from the synchrotransmitters to the electronic control amplifier (ECA).

Complete the statements below by underlining the correct answer(s).

1. The gyroscopic principle which enables the gyro to hold a fixed position is (rigidity, precession).

2. When the aircraft noses up or down, a signal is produced in the (pitch CX, roll CX).

3. When the aircraft banks left or right, a (pitch, roll, heading) signal is produced.

4. Attitude outputs from the transmitter synchros are transmitted to the (gyro platform, Electronic Control Amplifiers).

Answers to Frame 4: 1. Attitude 2. Universally 3. Vertical

1679

Frame 6

The vertical gyro (VG) references the aircraft attitude in pitch and roll through the use of synchro transmitters. In order to provide accurate output signals, the VG spin axis must be maintained perpendicular to the earth. To keep the VG level, electrolytic gravity switches (sensors) and torque motors are used. The sensors are mounted on the gyro or gyro gimbals and will sense an unlevel gyro in the pitch and roll axes. The electrolytic gravity switch is a glass tube partially filled with a conducting substance (mercury or sodium iodide). When the gyro is level (figure A, page 6, HO-403), the fluid does not make contact with the power leads; therefore, the torque motor (TM) cannot operate. If the gyro is not level (figure B), the fluid completes a circuit through one winding of the torque motor, causing the motor to operate. The torque motor applies a force causing precession which levels the gyro. When the gyro is precessed back to level, the circuit is again open. The winding of the torque motor that is energized determines the direction of applied force and the direction the gyro will precess to become level. Figure C shows the location of the electrolytic switches and torquers.

Complete the statements below by underlining the correct answer(s).

1. The VG spin axis is maintained perpendicular to the earth by (pitch and roll transmitting synchros, electrolytic gravity switches and torque motors).

2. Current will flow in the torquer when the VG (is, is not) level.

3. An unlevel condition of the VG will be sensed by the (electrolytic gravity sensor, torque motors).

4. The torque motors are controlled by (synchrotransmitters, gravity sensors).

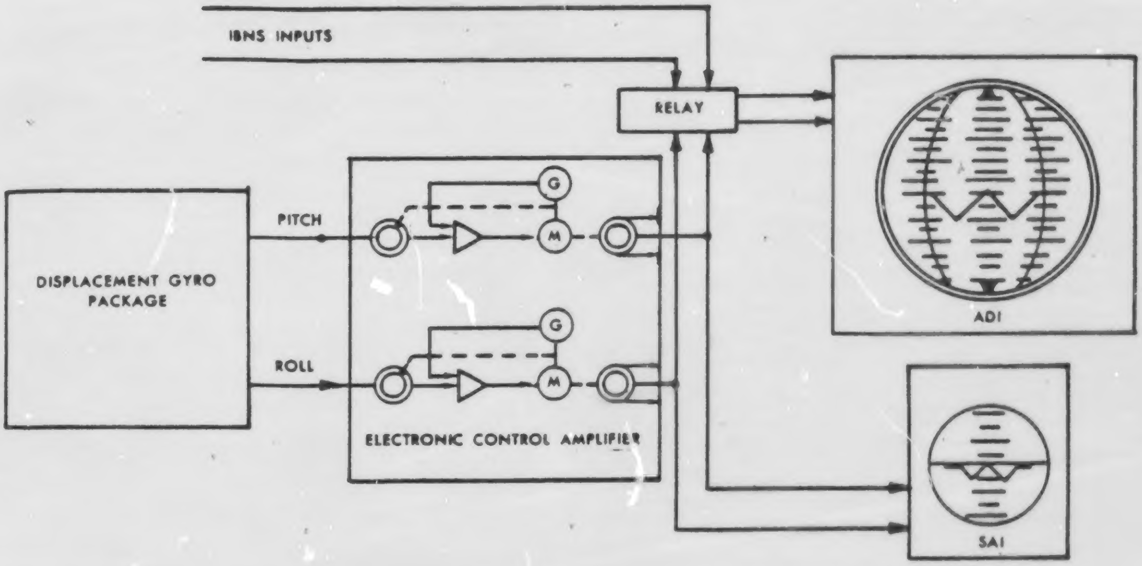
Answers to Frame 5: 1. Rigidity 2. Pitch CX 3. Roll

4. Electronic Control Amplifier

1752

The Electronic Control Amplifier (ECA) receives the synchro output signals from the displacement gyro (gyro platform). The roll and pitch signals are amplified and sent directly to the Standby Attitude Indicator (SAI) on the instrument panel. The SAI provides a visual display of the aircraft's attitude in the pitch and roll axis. Another indicator that displays the same information is the Attitude Director Indicator (ADI). The ADI normally operates on signals from the gyro in the Inertial Bomb Navigation System (IBNS). Under normal conditions with two indicators providing the same attitude indications, but operating from different reference gyros, the aircraft crew has a cross check of the systems and indicators.

Study the block diagram below to become familiar with signal flow through the system.


IBNS INPUTS
RELAY
ADI
PITCH
G
M
DISPLACEMENT GYRO PACKAGE
G
ROLL
M
ELECTRONIC CONTROL AMPLIFIER
SAI

Match the components in Column II to the statements in Column I. You may refer to the diagram.

Column I

_____1. Receives attitude outputs directly from the ECA.

_____2. Amplifies outputs from the displacement gyro.

_____3. Can receive outputs from both the IBNS and AFRS.

Column II

a. Attitude Director Indicator

b. Displacement Gyro Platform

c. Electronic Control Amplifier

d. Standby Attitude Indicator

Answers to Frame 6:
1. Electrolytic gravity switches and torque motor
2. is not
3. Electrolytic gravity sensor
4. gravity sensor

Refer to the schematic on page 7, HO-403, and visually trace the pitch and roll signals from the VG to the SAI and through each servo loop which positions the sphere.

The Standby Attitude Indicator receives pitch and roll signals from the ECA. Pitch and roll signals represent aircraft attitude in relation to the horizon. Both signals are applied to closed servo loops which consist of a control transformer (CT), an amplifier, a motor generator (MG) and mechanical linkage operated by the MG. Input signals are applied to the CT stators. The output signal, taken from the synchro rotors, is amplified. The amplifier output operates the motor generator which mechanically repositions the indicator sphere. The same mechanical linkage to the sphere also repositions the rotor of the CT to null the signal. Pitch and roll information read from the indicator sphere is referenced against a miniature aircraft symbol mounted on the front of the indicator.

Complete the statements below by underlining the correct answer(s).

1. Pitch and roll signals originate in the (SAI, electronic control amplifier, displacement gyro).

2. Signals from the rotor of the indicator CT are applied directly to (the sphere, an amplifier, a motor generator).

3. The indicator motor repositions the CT rotor to (dampen motor movement, null the signal).

4. Pitch and roll signals reference aircraft attitude in relationship to the (earth's horizon, longitudinal axis of the aircraft).

Answers to Frame 7: d 1. c 2. a 3.

Frame 9

The Standby Attitude Indicator (SAI) provides visual indications of aircraft attitude throughout 360 degrees of roll, but it is limited in pitch to 90 degrees. Pitch indications are referenced against the Miniature Aircraft Symbol (figures A and B, page 8, HO-403) and read on the horizontal scale on the sphere. Each horizontal line indicates five degrees. Roll indications are read from the Bank Angle Scale at the bottom of the indicator (figure B). This scale is marked at 10, 20, 30, 60 and 90 degree segments on both the left and right side of the scale. The bank index moves with the sphere to provide indications of the degree of aircraft roll (bank). On the lower left of the sphere is a "Power-Off" flag, which indicates either power failure or that the displacement gyro has not reached stability (figure C). It takes approximately two minutes after power application to the system for the flag to be removed from view.

Complete the following statements by underlining the correct answer(s).

1. The sphere provides attitude indications throughout (90° pitch and 360° roll, 90° roll and 360° pitch).

2. Pitch indications are read against the (bank index and miniature aircraft, miniature aircraft and horizontal lines on the sphere).

3. Roll indications are indicated (every 10 degrees, at 10, 20, 30, 60 and 90 degrees).

4. The Power-Off flag disappears after (1, 2, 3, 4) minutes of power application.

Answers to Frame 8: 1. displacement gyro 2. an amplifier

3. null the signal 4. earth's horizon

Because of structural design (configuration), carrying fuel and added weight (load), most aircraft must fly with a slight noseup attitude. On the lower right of the SAI is a "Pitch Trim Knob" (figure E, page 8, HO-403). It is used by the pilot to adjust the indicator sphere in the pitch axis to indicate straight and level flight. Figure D, page 8, HO-403, shows an aircraft with its nose up due to load and configuration. Figure C shows the indication on the SAI before adjustment. Figure E shows the sphere with an adjusted indication.

Complete the following statements by underlining the correct answer(s).

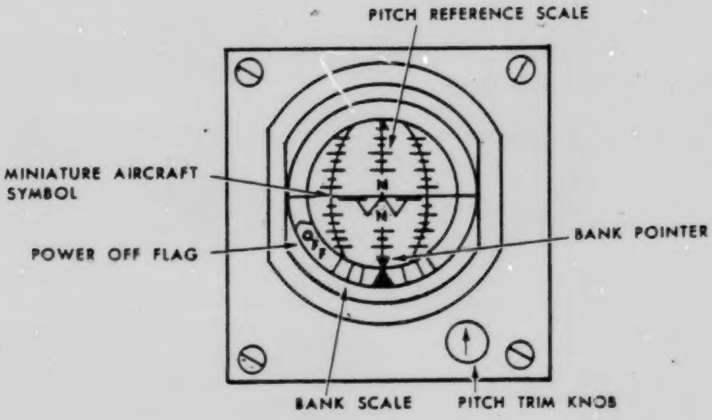
1. The adjustment knob on the SAI controls the sphere in its (roll, pitch) axis.

2. Load indication is due to (indicator alignment, added weight aboard).

Answers to Frame 9:
1. 90° pitch and 360° roll
2. miniature aircraft horizontal lines on the sphere
3. at 10, 20, 30, 60 and 90
4. 2

Frame 11

The Attitude Director Indicator (ADI) (see illustration below), provides visual indications of aircraft attitude. This indicator is located on the pilot's instrument panel and is the primary source of pitch and roll information. Operation of the attitude sphere in the ADI is the same as that covered in the Standby Attitude Indicator operation, except the sphere in the ADI also provides heading indications which will be covered in Section B of this text. Pitch, roll and heading indications are read against the miniature aircraft symbol. Pitch increments on the ADI sphere provide indications at every 10 degrees. Roll increments at the bottom of the indicator are at 10, 20, 30, 60 and 90 degrees. This indicator also has a "Pitch Trim Knob" provided for load and configuration adjustments. The "Power-Off" flag operates the same as that on the SAI.



Match the ADI component in Column II to the statements in Column I.

Column I

_____1. Is marked at increments of 10, 20, 30, 60 and 90 degrees.

_____2. Normally is out of view after two minutes of initial power.

_____3. Used to compensate for load and configuration indications.

_____4. References pitch, roll and heading information.

Column II

a. Pitch Trim Knob

b. Sphere

c. Power OFF Flag

d. Bank Angle Scale

e. Miniature Aircraft Symbol

_____5. Comes into view whenever power is lost.

_____6. Contains pitch increments (markings) every five degrees.

_____7. When turned, will position the sphere in its pitch axis.

Answers to Frame 10: 1. Pitch 2. added weight aboard

Frame 12

During normal flight conditions, the "Flight Instrument Reference Switch" in the cockpit is at the "Prim" (Primary) position. Attitude inputs to the SAI are received directly from the Auxiliary Flight Reference System, but attitude signals to the ADI are received from the Inertial Bomb Navigation System. First, we will cover system operation with the "Prim-Aux" switch in the "Prim" position. Refer to the schematic on page 9 in HO-403, and locate the "Prim-Aux" switch (Flight Instrument Reference switch). Visually trace the Primary Good signal from the IBNS to relay K1 in the Instrument Set Coupler. Now, visually trace the ground lead for relays K2 and K3 in Misc. Relay Panel number 1 through the closed contacts of K1. When energized, relays K2 and K3 provide a path for the pitch and roll signals from the IBNS, to the ADI. When relays K2 and K3 are not energized (contacts up), pitch and roll inputs to the ADI are received from the VG in the AFRS.

Complete the following statements by underlining the correct answer(s). You may refer to the schematic on page 9 in HO-403.

1. The Flight Instrument Reference Switch is normally placed in the (PRIM, AUX) position.

2. With the Flight Instrument Reference Switch in the "Prim" position, relays (K1, K2, K3) will be energized.

3. With power applied to the system and the Flight Instrument Reference switch in the "Prim" position, signals to the ADI are received from the (IBNS, AFRS).

4. When the Flight Instrument Reference Switch is in the (Prim, AUX, either Prim or AUX), inputs to the SAI are received from the AFRS vertical gyro.

5. The AFRS vertical gyro supplies signals to the ADI when relays K2 and K3 are (energized, deenergized).

Answers to Frame 11: d 1. c 2. a 3. e 4. c 5.

b 6. a 7.

The Auxiliary Flight Reference System supplies pitch and roll information to both the Standby Attitude Indicator and the Attitude Director Indicator, when the Flight Instrument Reference Switch is positioned to "AUX." Refer to the schematic on page 10 in HO-403. Notice that the PRIM-AUX switch is in the "AUX" position, thereby removing the IBNS primary good signal from relay K1 in the Instrument Set Coupler (ISC). The contacts of K1 will be up which deenergizes K2 and K3 in the Misc Relay Panel #1. With the contacts of K2 and K3 up, visually trace the pitch and roll signals from the AFRS (displacement gyro) through the pitch and roll modules in the Electronic Control Amplifier (ECA). The outputs of the ECA are applied directly to the SAI to operate the sphere. Pitch and roll outputs from the ECA also are sent through the contacts of K2 and K3 to be applied to the ADI to operate its sphere.

Referring to the schematic on page 10 in HO-403, complete the following statements by underlining the correct answer(s).

1. With the Flight Instrument Reference Switch in the "AUX" position, all relays are (energized, deenergized).

2. When the Flight Instrument Reference Switch is in the "AUX" position, the (IBNS, AFRS) supplies inputs to the Standby Attitude Indicator.

3. When the Flight Instrument Reference Switch is in the "AUX" position, the (IBNS, AFRS) supplies inputs to the Attitude Director Indicator.

4. The AFRS vertical gyro supplies signals to the ADI when relays K2 and K3 are (energized, deenergized).

Answers to Frame 12: 1. Prim 2. K1, K2, K3 3. IBNS

4. either Prim or AUX 5. deenergized

Frame 14

Relay K1 will be energized, only when the "Prim-Aux" switch is in the "Prim" position and the pitch and roll signals from the IBNS are strong enough to be relied on. In the event of failure of the IBNS gyro or a loss of either the IBNS pitch or roll signal, the primary good signal will not have sufficient strength to hold relay K1 energized. In the event that K1 deenergizes, the system's operation will automatically be the same as if the "Prim-Aux" switch was placed in the "AUX" position. The SAI and ADI will receive attitude input signals from the Auxiliary Flight Reference System.

Referring to page 10 of HO-403, complete the following statements by underlining the correct answer(s).

1. The primary good signal energizes K1 when the (AFRS, IBNS) pitch and roll signals are strong enough to be relied on.

2. In event of an IBNS gyro failure, relays (K1, K2, K3) will deenergize.

3. With a loss of the primary good signal, system operation automatically goes into (PRIM, AUX).

Answers to Frame 13:
1. deenergized
2. AFRS
3. AFRS
4. deenergized

Answers to Frame 14:
1. IBNS
2. K1, K2, K3
3. AUX

Frame 15 1690·

Match the components in Column II to the statements in Column I.

Column I

____ 1. Amplifies outputs from the Displacement Gyro Package.

____ 2. Can receive outputs from both the IBNS and AFRS.

____ 3. Determines whether attitude signals will be received from IGNS or AFRS.

____ 4. Receives attitude signals directly from the Electronic control amplifier.

____ 5. Receives attitude signals from the AFRS only.

Column II

a. Attitude Director Indicator

b. Displacement Gyro Package

c. Electronic Control Amplifier

d. Instrument Set Coupler

e. Primary-Auxiliary Switch

f. Standby Attitude Indicator

Complete the following statements by underlining the correct answer(s).

6. (Rigidity, Precession) is the gyroscopic principle which enables the gyro to hold a fixed position.

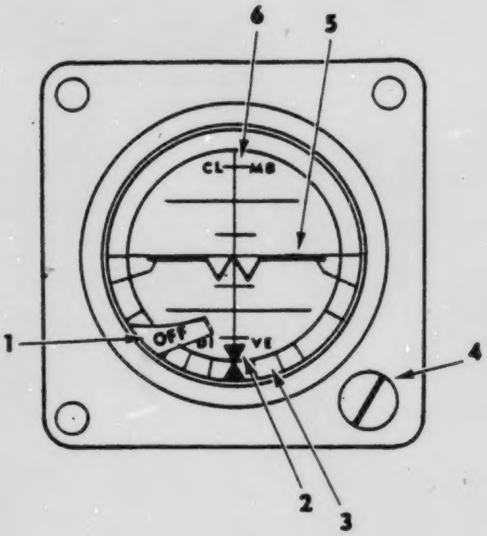
7. The (electronic control amplifier, displacement gyro platform) receives attitude signals from the transmitter synchros.

8. VG torquers are controlled by (electrolytic gravity sensors, synchro transmitters).

9. The adjustment knob on the SAI controls the sphere in its (roll, pitch) axis.

10. Changes in aircraft attitude are sensed by (synchrotransmitters, torque motors).

1691 Match the items in the illustration below to their terms or statements. Numbers may be used more than once.



(___)11. Bank Angle Scale

(___)12. Bank Index

(___)13. Comes into view when power is lost

(___)14. Adjusted to compensate for load and configuration errors

(___)15. Miniature aircraft symbol

(___)16. Pitch and Roll Sphere

(___)17. Pitch Trim Knob

(___)18. Power Off Flag

Answers to Frame 15: c 1. a 2. e 3. f 4. f 5. 6. rigidity 7. electronic control amplifier 8. electrolytic gravity sensors 9. pitch 10. synchrotransmitters (3) 11. (2) 12. (1) 13. (4) 14. (5) 15. (6) 16. (4) 17. (1) 18.

If you have missed any questions in Frame 15, return to the appropriate frame to insure a complete knowledge of the materials presented in Section A, then proceed to Part II.

PART II - Detailed Description of the Attitude Reference System.

SPECIAL INSTRUCTIONS

Obtain Handout 3ABR32531-HO-403A from your instructor and trace circuits as outlined in this section. When you have completed this section, have your instructor check your work.

Frame 1

HO-403A (AFRS Attitude System schematic) will be completely covered in this portion of the text. Learning the detailed operation of the attitude system by using the schematic will provide you with the necessary knowledge for troubleshooting the system on the trainers. Interspersed throughout this section will be instructions for tracing power and circuits using various colors for circuit distinction. Refer to the schematic in HO-403A and notice that it contains components and a test board that were not covered previously. These additional components and portions of the components that you will learn about were not covered in Part I of Section A to keep the basic system operation as simple as possible.

NO RESPONSE REQUIRED

Consider what happens when the systems AC and DC switches are closed. Power is applied from the AC and DC sources, into the electronic control amplifier (ECA). From here it is distributed to various components and units. Reference voltage, 26V AC, is applied to synchro rotors in both the ECA and Displacement Gyro Package (DGP). Refer to HO-403A and locate these synchros. The vertical gyro (VG) spin motor receives 115V AC for its operation. In order for the VG to produce accurate pitch and roll signals it must be leveled. For a review of the pitch and roll sensor and torque operation refer to Frame 6, PT 403, Section A, Part I. To provide fast erection of the VG, 78V AC is applied to the erection torquers for the first two minutes of operation. After the first two minutes of operation, the erection torquer voltage is decreased to 26V AC for normal erection.

Complete the following statements by underlining the correct answers shown in parenthesis.

1. The (DGP, ECA) receives power directly from the AC and DC sources.

2. Power is distributed to the systems components from the (ECA, DGP).

3. Power is applied to the synchro (ROTORS, STATORS).

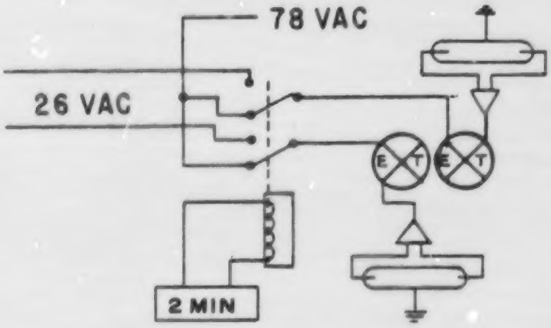
4. (26V AC, 115V AC, 28V DC) is applied to the VG spin motors.

5. To provide fast erection of the VG, (26V AC, 78V AC, 115V AC) is applied to the erection torquers.

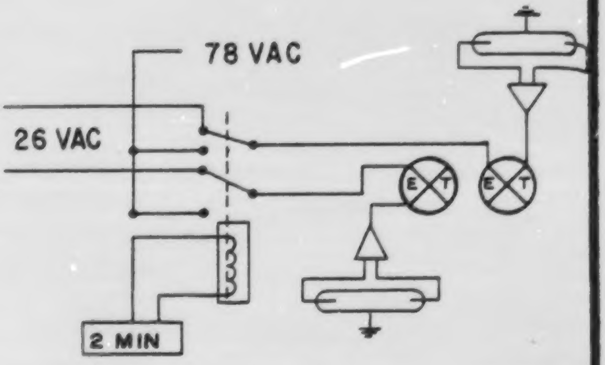
6. Fast erection of the VG is accomplished during the first (30 sec, 1 min, 2 min) of system operation.

Frame 3

Fast erection voltage is obtained during the first two minutes by a two-minute time delay relay. Refer to HO-403A and locate the time delay relay in the DGP. During the first two minutes the time delay relay is energized and the relay contacts are in the down position, applying 78V AC to the torquers. After two minutes, the relay de-energizes and the relay contacts return to the up position, providing a path for 26V AC to the torquers. Refer to the illustration below for a better understanding of the relay portion.



First 2 Min. of Operation



After first 2 Min. of Operation

Complete the following statements by underlining the correct statement shown in parentheses.

1. During the first two minutes of operation the time delay (energizes, deenergizes) its relay.

2. When the time delay relay is energized (78V AC, 26V AC) is applied to the erection torquers.

3. After two minutes of system operation, the time delay relay contacts will be (up, down).

Answers to Frame 2:

1. ECA, 2. ECA, 3. ROTORS, 4. 115V AC, 5. 78V AC, 6. 2 min

Frame 4

During the first two minutes of operation you will find that the power warning flags will be in view. The malfunction detector located in the ECA amplifier (HO-403A) receives 78V AC which provides the necessary circuitry to keep the flags in view for the first two minutes. Located below the malfunction detector is relay K-38 which is maintained deenergized by the detector for the first two minutes. When K-38 is not energized the AUX ATT light in the cockpit is on and the ADI and SAI flags will be in view.

Complete the following statements by underlining the correct answers shown in parentheses.

1. During the first two minutes of operation, the ADI and SAI warning flags will be (in, out of) view.

2. Relay K-38 is (energized, deenergized) during the first two minutes.

3. When power is first applied, relay K-38 provides the path to keep the AUX ATT light (off, on).

4. After two minutes of operation the AUX ATT light in the cockpit is (on, off).

Answers to Frame 3:

1. energizes, 2. 78V AC, 3. up

Frame 5

NOTE: This frame contains instructions for tracing power to the system when initial power is turned on. Answer the questions following these tracing instructions.

Use a red pencil to trace the following circuitry:

1. From the AC Power Panel, trace the A, B, and C phase of power into the electronic control amplifier power supply.

NOTE: Power wiring is not shown drawn throughout the components. This is to reduce the confusion of a lot of wiring. Power is shown at the points where it is used.

Continue tracing the three phase power at the left of pins 80, 81, and 82 of the first board, into the DGP to operate the VG spin motor.

2. Trace the 26V AC power to the synchro rotors in the DGP and ECA.

3. Trace from the 2 min time delay in the DGP, up to the relay. Draw, in red, the relay contacts to the down position. Trace the 78V AC (above the relay contacts) through (the now down contacts) to the erection torquers.

4. Locate the tie point to the right of the top relay contact. Trace the 78V AC out pin 4 of the DGP (P1) to the malfunction detector in the ECA.

NOTE: Recall that when 78V AC is applied to the malfunction detector relay K-38 in the ECA will not energize, allowing the AUX ATT light in the cockpit to be on.

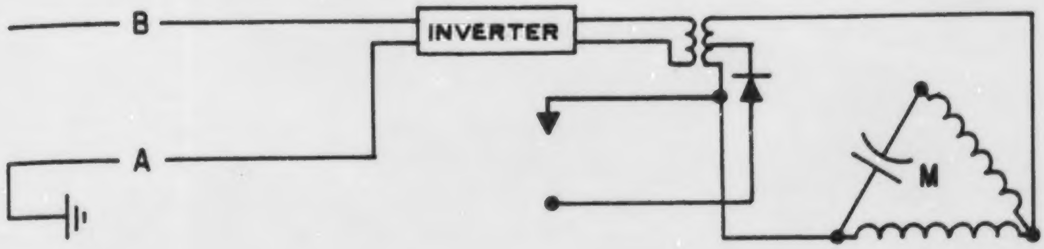
5. Trace the DC voltages from the 28V DC ESS BUS (left side of diagram), through pin 27 of P1 of the ECA, through the top contacts of relay K-38. Continue out pin 28 of P1 to the AUX ATT light.

NOTE: Because K-38 in the ECA is not energized for the first two minutes, relay K1 in the instrument set coupler is not energized. Therefore, with no ground for the power flags, they will be in view.

6. Power for operation of the Rate Gyro Transmitter: Trace the 28V DC into pin B of P9 on the Rate Gyro Transmitter. Continue through the inverter to the primary of the transformer.

NOTE: The Inverter changes DC to AC. With the loss of AC power the pilot still has the use of the rate of turn pointer which can operate off of battery power from the aircraft.

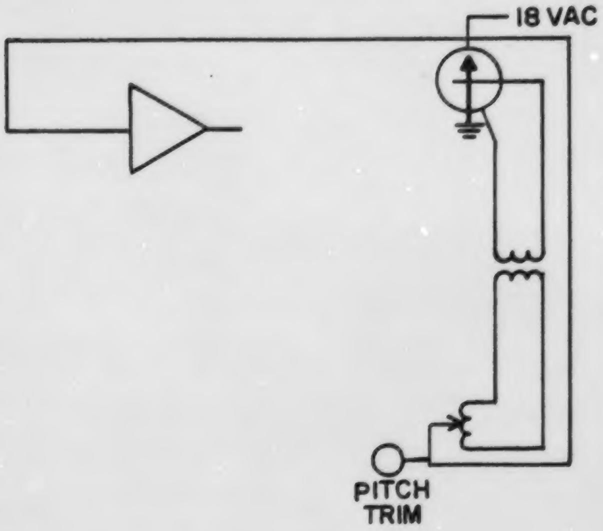
Continue the circuitry from the transformer secondary to the gyro motor and to the balance bridge as shown below. The figure below shows only the circuitry to be traced on HO-403A.



NOTE: Outputs and pins C and D are signal outputs to the rate of turn pointer and will be traced at a later time.

1699

7. Pitch trim reference voltage: Trace the 18V AC, in the ADI through the Pitch Trim Fade Pot to the Pitch Trim Pot. Continue from the Pitch Trim Pot to the Pitch amplifier as shown below. The figure below shows only the circuitry to be traced on HO-403A.



NOTE: Operation of the Pitch Trim Knob is covered in Frame 10 of PT 403, Section A.

1772

Circle the number preceeding the following true statements.

1. 78V AC is applied to the malfunction detector after the first two minutes of system operation.

2. During the first two minutes of operation, the contacts of relay K-38 allow the AUX ATT light to be on.

3. Relay K-1 in the Instrument Set Coupler is energized by relay K-38 for the first two minutes of operation.

4. 115V AC is applied from the system power supply directly to the rate of turn gyro.

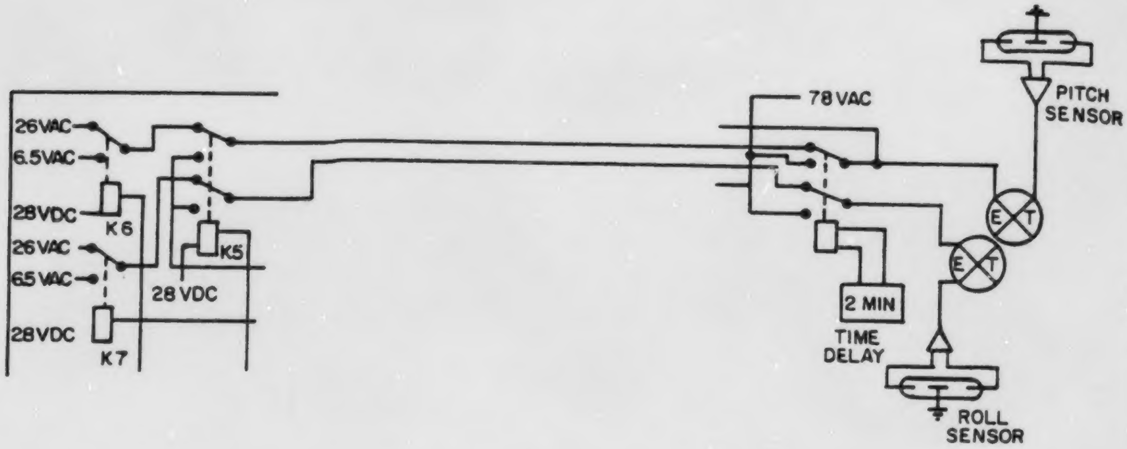
5. DC is applied to the Rate Gyro Transmitter and converted to AC to operate its gyro.

Answers to Frame 4:

1. in, 2. deenergized, 3. on, 4. off

1701
Frame 6

After the first two minutes of system operation, the DGP time delay relay deenergizes. The contacts of the relay return to their normal up position. At this time the gyro is leveled. Therefore, only 26V AC to the torquers is needed to keep the gyro level. The 26V AC is transmitted through relays K-6 and K-7 in the ECA to the torque motors in the DGP. Refer to the illustration below for better understanding of normal system operation.


26VAC
6.5VAC
28VDC
K6
26VAC
6.5VAC
K5
28 VDC
28VDC
K7
78VAC
PITCH SENSOR
E
T
E
T
2 MIN
TIME DELAY
ROLL SENSOR

Complete the following statements by underlining the correct answers shown in parentheses.

1. After the gyro is leveled (6.5, 26, 78) V AC is applied to the torquers to keep the gyro level.

2. After two minutes of operation, the voltage to operate the erection torquers is received from the (DGP, ECA, ADI).

Answers to Frame 5:

1. [✓ 2.] 3. 4. [✓ 5.]

1774

Frame 7

As the time delay relay in HO-403A is deenergized, the 78V AC that was applied to the malfunction detector is also reduced to 26V AC. Note that the pitch and roll outputs from the DGP are also applied to the malfunction detector. If the gyro is level and these signals are valid, the malfunction detector will allow relay K-38 to energize. When the contact of K-38 pulled down, the circuit to the AUX ATT light is broken and the light goes out. Relay K-1 in the Instrument Set Coupler is energized by relay K-38. Relay K-1 now provides the ground for the ADI and SAI power warning flags. With the ground applied, these flags are biased out of view.

Circle the number preceeding the following true statements.

1. After two minutes of operation 78V AC is applied to the malfunction detector.
2. If, after two minutes of operation 26V AC and valid pitch and roll signals are applied to the malfunction detector, relay K-38 will energize.
3. Relay K-38, when energized, causes the AUX ATT light to come on.
4. Relay K-1 in the Instrument Set Coupler provides the ground to bias the power warning flags out of view.

Answers to Frame 6:

1. 26 2. ECA

1703

Frame 8

NOTE: This Frame provides tracing instructions.

1. Use a green pencil to trace the 26V AC from the upper left of the ECA through contacts of relays K-6 and K-7 into the DGP.

NOTE: The two-minute time delay relay is now deenergized. Continue tracing through the contacts of the relay to the erection torquers.

2. From the tie point located to the right of the top relay contact, trace in green (parallel to the red) to the malfunction detector.

3. In the ECA, trace the output leads (bottom of the malfunction detector) down to relay K-38 to show that the relay is energized. (Trace the contacts to the down position.)

4. Using green, trace parallel to the red from the DC Bus to the contacts of relay K-38. Continue through the down contacts of K-38 through K-1 in the Instrument Set Coupler to ground. Draw the contacts of K-1 down (energized).

5. Trace from ground through the contacts of the energized relay K-1, to the following:

a. Top contacts: trace out pin V of P1 through the Misc Switch Panel to the power warning flag in the ADI.

NOTE: When the PRI-AUX switch in the Misc. Switch Panel is in AUX (as shown), the ground to bias the ADI power warning flag out of view, is provided by the Instrument Set Coupler. If the pilot is operating in the Primary position and the ADI is receiving attitude signals from the IBNS, ground to bias the flag out of view, is provided by K-1 in the Misc. Switch Panel.

b. Bottom contact: trace out pin jj of P2 directly to the SAI to the power warning flag.

NO RESPONSE REQUIRED

Answers to Frame 7:

1. [✓ 2.] 3. [✓ 4.]

1776

Now that the system (after two minutes) is operating normally, we will consider that the DGP, pitch and roll synchros are providing valid and accurate signals to the two indicators (ADI and SAI).

Use a yellow pencil to trace the pitch and roll outputs of the DGP as instructed below.

1. Trace from the stator of both the pitch and roll synchros out pins 10, 11, 12, 13, 14 and 15 into the ECA. Trace the pitch output to the stator of the pitch synchro B6. Trace the roll output to the stators of roll synchro B5.

2. Note the parallel paths of both the pitch and roll outputs which are applied to the malfunction detector. Trace these pitch and roll signals (above synchro B5 and B6) to the left into the malfunction detector.

> NOTE: In the event that any one of the three pitch and roll stator leads to the malfunction detector is broken or the signal is not valid, the detector will cause relay K-38 to be deenergized. K-38, in turn, will cause the AUX ATT light to come on and the power warning flags to come into view.

3. Continue tracing with yellow, off of the rotors of B5 and B6 into amplifier A1 and A2. Trace the parallel lead, off of the rotor of both the pitch and roll signal, into the malfunction detector. Continue with the amplifier signal to the two motors. Trace the two servo loops.

   a. From each motor, trace the mechanical linkage to the rotors of output synchros B1 and B2.

   b. Trace the motor mechanical linkage to the generator dampening outputs back to the amplifiers.

   c. Trace the mechanical linkage back to the rotors of B5 and B6 to null out the signal.

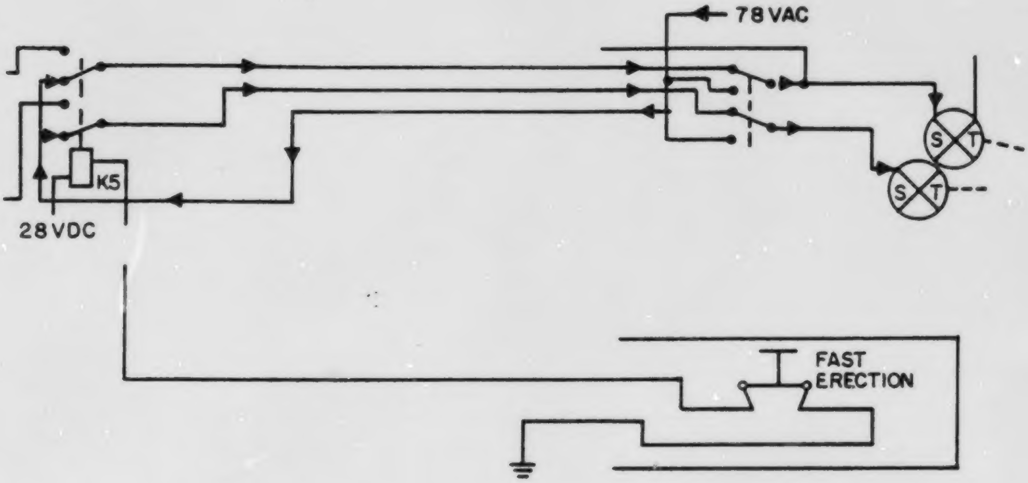
4. Trace the outputs from the stators of B1 and B2 out of the ECA into both the ADI and SAI. Trace the pitch and roll servo loops in both indicators to show that both indicators indicate pitch and roll attitude.

NO RESPONSE REQUIRED

1705

Frame 10

After prolonged turns or excessive maneuvers, the gyro may not have remained erect. A fast erection switch is provided on the Misc. Display Panel to provide for fast erection. Depressing this switch provides the ground to energize relay K-5 in the ECA. Refer to the illustration below and visually trace the ground, through the fast erection switch to relay K-5 in the ECA. With the contacts of relay K-5 down (as shown) 78V AC from the DGP has a path through these contacts to the erection torquers. Follow the arrows to determine the path of current flow to the torquers.



Complete the following statement by underlining the correct answer shown in parentheses.

1. The fast erection switch is located on the (DGP, Misc. Display Panel).

2. When the fast erection switch is depressed, relay (K-5, K-6, K-7) is energized.

3. Depressing the fast erection switch causes (6.5, 26, 78) V AC to be applied to the erection torquers.

1778

Use a purple pencil to trace the fast erection circuit.

1. In HO-403A, trace from ground, left of pin N on P514 of Misc. Display Panel, through the fast erection switch, out pin M. Continue tracing to relay K-5 in the ECA to 28 V DC to energize the relay.

2. Trace the relay contacts to the down (energized) position.

3. Trace the 78V AC in the DGP out of 8 of P1. Trace into the ECA, at pin 13 of P2, through the two contacts of relay K-5. Continue to parallel the two leads, that have been colored green, to the pitch and roll erection torquers in the DGP.

NO RESPONSE REQUIRED

Answers to Frame 10

1. Misc. Display Panel 2. K-5 3. 78

1767

Frame 12

Recall from Section A that the device used to sense when the gyro is not level, are pitch and roll sensors (electrolytic switches). These sensors provide the control phase to the pitch and roll erection torquers. Because these devices use fluid for their operation, they are also sensitive to aircraft turns and acceleration forces. During aircraft turns or periods of acceleration, the fluid in the sensors will displace from center causing the pitch and roll torquers to start operating even though the gyro is not out of level. If at this time the voltage to the torquers is not reduced, the torquers will precess the gyro to a false level.

Circle the number preceeding the true statements below.

1. Pitch and roll electrolytic switches, sense that the aircraft is accelerating or turning.

2. Aircraft turns and acceleration affect the torquers as if the gyro was not level.

1780

Frame 13

To reduce false erection, two sensors (turn and acceleration) are used to sense when the aircraft is acceleration or turning. These two sensors are electrolytic switches containing fluid. Whenever the aircraft turns or accelerates the fluid is displaced from center to provide a ground which energizes relays K-6 and K-7. Relays K-6 and K-7 are located in the ECA. When energized these relays reduce the erection torquer voltage from 26V AC to 6.5V AC. Reducing the erection torquer voltage, reduces the amount of false erection. Refer to HO-403A and visually trace from the two sensors to relays K-6 and K-7. Note that when these relays are energized by the sensors, the lower contacts provide the path for 6.5V AC to be applied to the torquers.

Circle the number preceeding the true statements below.

1. False erection is reduced by acceleration and turn sensors.
2. Acceleration and turn sensors are electrolytic switches.
3. During aircraft acceleration or turns the sensors energize K-5 in the ECA.
4. During acceleration and turns the erection torquers receives 78V AC.

Answers to Frame 12:

① ②

Frame 14

Use a brown pencil to trace the false erection-reduction circuit.

1. Trace from the two grounds through the turn accelerometer sensor and the accelerometer sensor out pin 9 and 16 of P1 on the DGP. Continue into the ECA to and through relays K-6 and K-7.

2. Trace the contacts of K-6 and K-7 to the down (energized) positions.

3. Trace the 6.5V AC through the down contacts of K-6 and K-7 through the up contacts of relay K-5. Continue to parallel the two leads, which have already been traced purple and green, to the pitch and roll erection torquers.

NO RESPONSE REQUIRED

Answers to Frame 13:

[✓ 1.] [✓ 2.] 3. 4.

Located at the base of the ADI, is a rate of turn pointer. This pointer is controlled by the rate gyro transmitter located above the ADI on HO-403A. Operation of the rate of turn pointer was covered in the Bank and Turn PT.

Use a blue pencil to trace the rate of turn circuitry.

1. Trace from the bridge network in the Rate Gyro Transmitter, out pins C and D of P9.

2. Trace from pins C and D into the ADI to the rate of turn meter movement.

NO RESPONSE REQUIRED

1711

Frame 16

Refer to HO-403A and note that the AC power from the AC power panel must pass through the contacts of the AFRS Power Relay K-1 before entering the ECA. This relay is energized when the GYRO-OFF switch on the ground check panel is positioned to OFF. When this relay is energized, no power is applied to the gyros. This switch is positioned to OFF when it is necessary to have power applied to the system but not necessary for the gyros to be in operation.

Complete the following statements by underlining the correct answer shown in parentheses.

1. The GYRO-OFF switch is located on the (DGP, Ground Check Panel).

2. When the GYRO-OFF switch is in the (GYRO, OFF) position power is applied to gyros.

3. Power is removed from the gyros when the AFRS Power Relay K-1 (is, is not) energized.

After completion of this text check the master diagram to determine if you have traced the circuits correctly.

Answers to Frame 16:

1. Ground Check Panel   2. Gyro   3. is

APPRAISAL

1713

SECTION B - GYRO STABILIZED MAGNETIC COMPASS SYSTEM

Section B is designed to teach you the components, component operation and modes of operation of the Gyro Stabilized Magnetic Compass System.

SPECIAL INSTRUCTIONS

Illustrations and diagrams from pages 11 through 13 in HO-403 will be used with this section of the text.

Frame 1

The AFRS furnishes both attitude and heading reference signals to the indicators. Now you will cover the heading portion, which is actually a Gyro Stabilized Magnetic Compass System. What is a Gyro Stabilized Magnetic Compass System? It is a system which uses a directional gyro (DG) to provide heading signals to an instrument which indicates aircraft direction. Because the DG drifts due to the earth's rotation, the DG heading output signal would be inaccurate if not corrected. This error is compensated for by a direction sensing component that senses the north-south direction of the earth's magnetic field. This sensing unit produces a signal that maintains the gyro at its original reference position, thereby correcting for drift. The sensing unit, by correcting for drift is in a sense referencing the DG to the earth's N-S magnetic field. Therefore, the input to the indicator is a Gyro Stabilized Magnetic heading signal.

NO RESPONSE REQUIRED

Frame 2

The major components of the compass system are the Displacement Gyro, Electronic Control Amplifier, Compass System Controller and Remote Compass Transmitter. You may recall from Frame 1 of Section A that these components are the same as the components of the complete Auxiliary Flight Reference System. When covering the attitude portion of the AFRS, we learned how the Displacement Gyro and Electronic Control Amplifier affected the Attitude Reference System. These two components will be covered again with the addition of the Remote Compass Transmitter and Compass System controller. Three indicators that can receive heading outputs from the Compass System are the Bearing Distance Heading Indicator, Horizontal Situation Indicator and the Attitude Director Indicator.

Study the block diagram on page 11, HO-403, to become familiar with the components, subcomponents, and indicators in the complete Gyro Stabilized Compass System.

From the block diagram on page 11, HO-403, list the following in the spaces provided:

1. The major components of the Gyro Stabilized Compass System.
2. Indicators which receive heading signals from the compass system.

1. a. ______________________ 2. a. ______________________

b. ______________________ b. ______________________

c. ______________________ c. ______________________

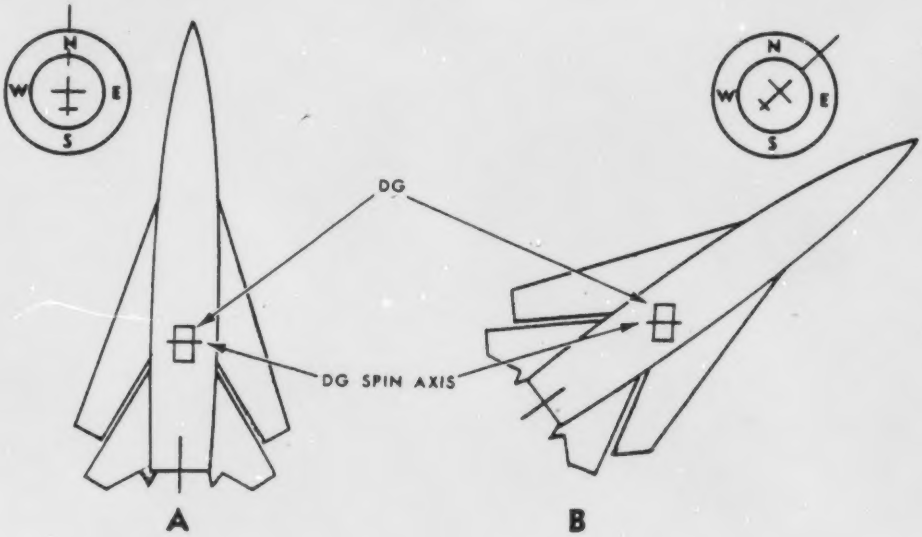
d. ______________________

1715

Frame 3

The first component that will be covered is the Displacement Gyroscope. The previous section stated that the displacement gyro package has a vertical gyro with its spin axis maintained perpendicular to the earth. The function of the VG is to provide pitch and roll (attitude) signals. The same displacement gyro package also contains a directional gyro (DG). Its spin axis must be maintained parallel to the earth. The function of the DG is to produce accurate heading outputs which are used to indicate aircraft direction.

Study the drawings below. Notice that the aircraft has changed direction (figure B) but the gyro held a fixed position and the indicator indicates the new aircraft heading.



Mark the following statements True (T) or False (F).

_____1. The Vertical Gyro produces heading signals.

_____2. As the aircraft turns, the DG holds a fixed position.

_____3. Signals produced by the DG represent aircraft heading.

_____4. The DG must have a vertical spin axis.

_____5. The spin axis of the DG is held parallel to the earth.

Answers to Frame 2: 1.
- a. Displacement Gyro
- b. Electronic Control Amplifier
- c. Remote Compass Transmitter
- d. Compass System Controller

2.
- a. Horizontal Situation Indicator
- b. Bearing Distance Heading Indicator
- c. Attitude Director Indicator

Like the VG, the DG also must be leveled to produce an accurate reference signal. This is accomplished through the DG leveling sensor (leveling pick off). This leveling sensor is mounted between the DG inner and outer gimbal. It consists of two transformer windings with one winding attached to each gimbal. When the DG is level, figure A, there is no voltage output to the torquer because one coil will not induce a voltage into another coil that is positioned 90 degrees to it. If the DG drifts or moves away from level, figure B, the angle relationship between the two coils of the transformer change. As the angle changes, a voltage is induced in the secondary. The direction the rotor and coil move will determine the polarity of the voltage. This output is amplified and sent to one phase of the torque motor. The other phase of the motor is a fixed phase. The voltage to the torque motor tries to turn the gyro which causes it to tilt until it is level. When the gyro is level, the transformer windings are perpendicular (90 degrees) to each other and no voltage is induced.

Study the drawings below to determine how this leveling of the DG takes place.

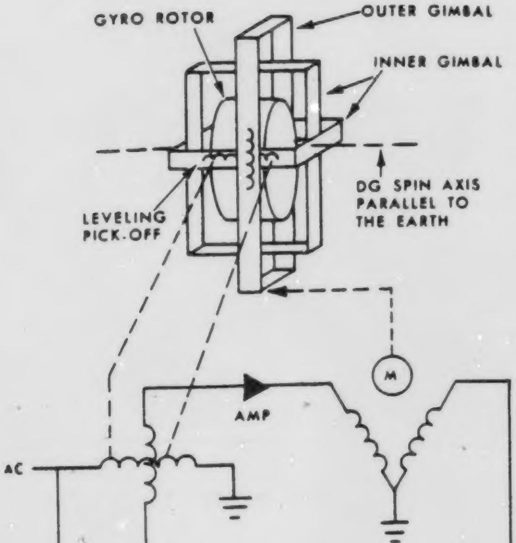

GYRO ROTOR
OUTER GIMBAL
INNER GIMBAL
LEVELING PICK-OFF
DG SPIN AXIS PARALLEL TO THE EARTH
M
AMP
AC

Figure A.
Directional Gyro Level

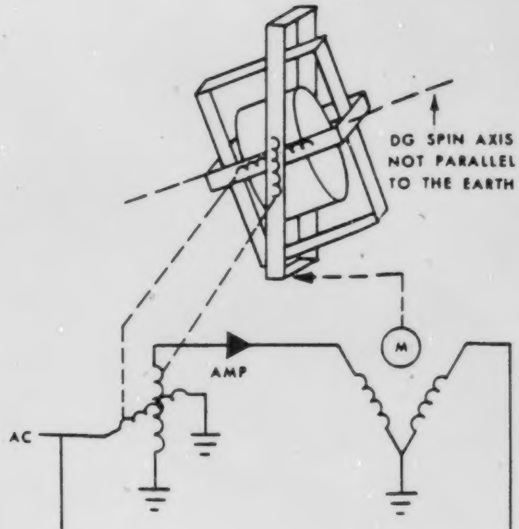

DG SPIN AXIS NOT PARALLEL TO THE EARTH
M
AMP
AC

Figure B.
Directional Gyro Unlevel

17/7.

Complete the statements below by underlining the correct answer.

1. To be accurate, the directional gyro spin axis is kept (perpendicular, horizontal) to the earth.

2. The DG leveling sensor output is applied to the (torque motor, gyro) motor.

Answers to Frame 3:

1. F 2. T 3. T 4. F 5. T

When the directional gyro is operating and leveled, rigidity causes it to hold a fixed position. As the aircraft turns, the displacement gyro case turns with the aircraft, while the gyro and the outer gimbal hold a fixed position. Refer to page 12 in HO-403 to locate and determine the relationship between the gyro, outer gimbal, and displacement gyro case. Any change in aircraft direction (heading) will be sensed by a synchrotransmitter located between the outer gimbal and case (refer to diagram). The displacement between the rotor and stator of the synchrotransmitter, produces a change in the electrical output on the rotor, which is transmitted to the Electronic Control Amplifier (ECA). The ECA amplified output operates the directional indicator. Study figures A and B on page 12 of HO-403 and note the relationship between outer gimbal and the case before and after a turn. Also note the heading change on the indicator.

Complete the following statements by underlining the correct answer(s).

1. Changes in aircraft heading are sensed by (a leveling sensor, a synchrotransmitter).

2. When the aircraft changes its heading, the (outer gimbal, case) turns with it.

3. Outputs from the synchrotransmitter are sent to the (displacement gyro, electronic control amplifier).

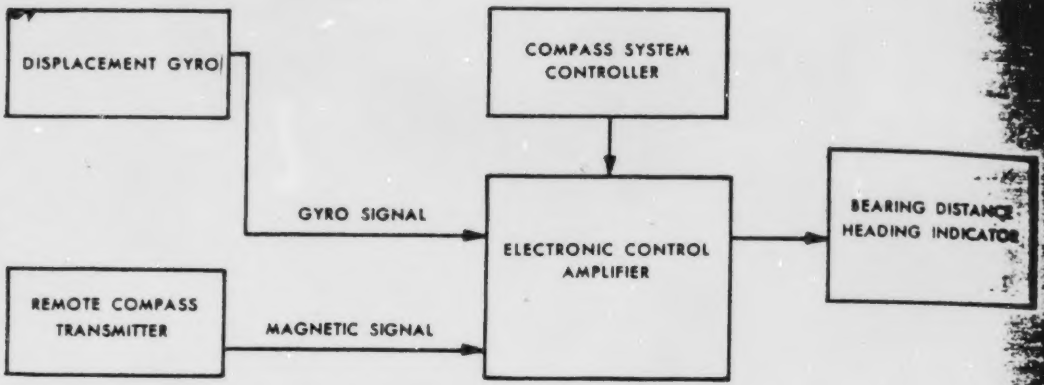
Answers to Frame 4:

1. horizontal or parallel 2. torque motor

Frame 6

The heading reference signal from the Directional Gyro (DG) is sent to the Electronic Control Amplifier. The Electronic Control Amplifier also receives heading reference signals from the remote compass transmitter. So we have two heading reference signals fed into the Electronic Control Amplifier. How these signals are used is determined by the Compass System Controller. The compass system controller controls and monitors the compass system (heading reference). It has a selector switch which controls relays in the electronic control amplifier. When a switch position is selected, the amplifier will process the appropriate signal, amplify it and transmit it to the indicators or other components in the system.

Study the drawing below to determine what two signals are sent to the Electronic Control Amplifier and what controls the use of these signals.


DISPLACEMENT GYRO
COMPASS SYSTEM CONTROLLER
GYRO SIGNAL
ELECTRONIC CONTROL AMPLIFIER
BEARING DISTANCE HEADING INDICATOR
REMOTE COMPASS TRANSMITTER
MAGNETIC SIGNAL

Mark the statements below True (T) or False (F).

_____1. The compass system controller is a switch panel.

_____2. The signals are routed through the Electronic Control Amplifier to the compass controller.

_____3. The Remote Compass Transmitter produces a magnetic heading signal.

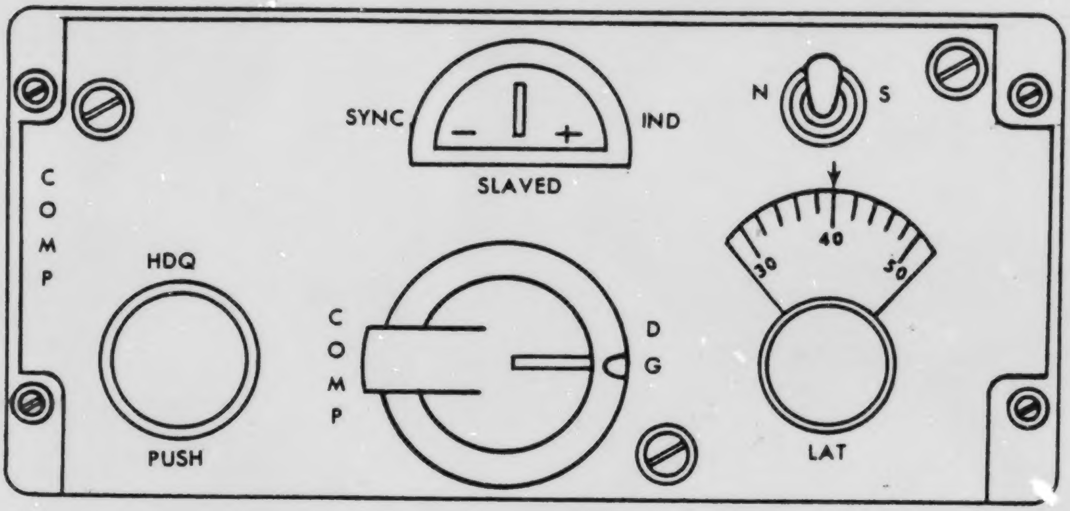
_____4. The heading signal is processed, amplified and sent to the Bearing Distance Heading Indicator.

Answers to Frame 5:

1. a synchrotransmitter 2. case 3. electronic control amplifier

The Compass System Controller (CSC) is located in the cockpit and enables the pilot to control and monitor the compass system. On the lower center of the controller is the mode selector switch used to select a particular mode of operation for specific flight conditions. Above the mode selector switch is a "Sync Indicator" which indicates to the pilot if the system signals are synchronized or not (center position means synchronized and that the indicator is indicating correctly). On the left is a "heading" set knob which enables the pilot to set the indicator compass card to any indication desired. To the right of the mode selector switch is a "Latitude Correction Knob" used in the DG mode to set the amount of correction required for apparent drift. It is set to the latitude that the aircraft is flying. Above the latitude correction knob is a N - S hemisphere selector switch used in the DG mode. It is positioned to the hemisphere, either N or S, that the aircraft is flying in.

Study the drawing below to become familiar with the switches and indicators on the Compass Controller.



Match the component function to its name.

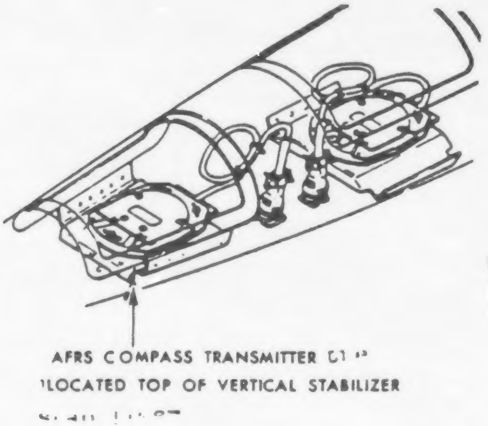
____1.	Is set to a particular latitude.	a.	Mode selector switch
____2.	Tells when the indicators are reading correctly.	b.	Hemisphere selector switch
____3.	Placed in the "N" position above the equator.	c.	Heading set knob
____4.	Set for a particular method of operation.	d.	Latitude correction knob
____5.	Rotates the compass card to a desired heading.	e.	Synchronization indicator

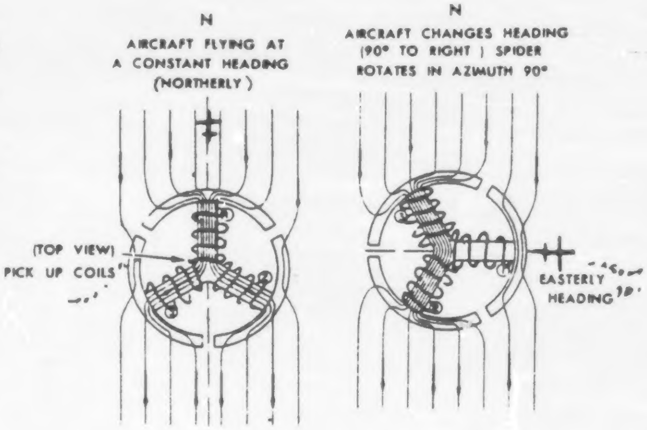
Answers to Frame 6: __T__ 1. __F__ 2. __T__ 3. __T__ 4.

Frame 8

A "Remote Compass Transmitter" furnishes a magnetically induced electrical heading signal to the Electronic Control Amplifier. This component is the system magnetic direction sensing unit. Its magnetic heading output is used to prevent gyro drift, or, when applied to the indicators, to give aircraft magnetic heading. It consists of three pick-up coils which resemble synchrostators. These coils sense the North-South direction of the earth's magnetic field. The compass transmitter is mounted with one pick-up coil on the aircraft longitudinal axis. As the aircraft turns, the pick-up coils turn, changing the direction that the earth's magnetic field cuts the coils. The amount the aircraft turns will determine the amount of change in the output of the coils. The changing output represents the amount of change in aircraft heading (direction).

Study the drawings below to determine where the transmitter is located and how the angle of the pick-up coils in relation to the earth's magnetic field determines the voltage output signal.


AFRS COMPASS TRANSMITTER
LOCATED TOP OF VERTICAL STABILIZER


N
AIRCRAFT FLYING AT
A CONSTANT HEADING
(NORTHERLY)
N
AIRCRAFT CHANGES HEADING
(90° TO RIGHT) SPIDER
ROTATES IN AZIMUTH 90°
(TOP VIEW)
PICK UP COILS
EASTERLY
HEADING

Mark the statements below True (T) or False (F).

_____1. The remote compass transmitter senses the direction of the earth's magnetic field.

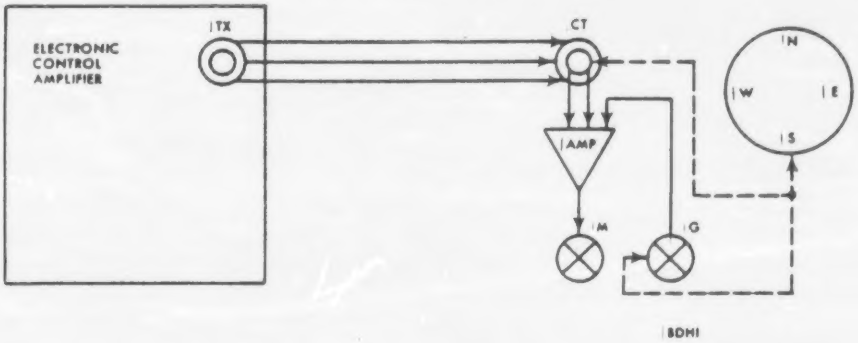
_____2. The remote compass transmitter is located in the cockpit.

_____3. One leg of the transmitter is positioned on the longitudinal axis of the aircraft.

_____4. The position of the pick-up coils does not affect the output signal.

Answers to Frame 7: _d_ 1. _e_ 2. _b_ 3. _a_ 4. _c_ 5.

The next component to be considered is the Bearing Distance Heading Indicator (BDHI). This indicator presents heading information to the copilot. The signal to the indicator is produced by the Auxiliary Flight Reference System (AFRS). This signal is processed and amplified in the Electronic Control Amplifier (ECA) before being applied to the BDHI. The output of the ECA is applied to a closed servo loop which consists of a control transformer that receives the signal, an amplifier, a motor generator which mechanically operates the dial or compass card and nulls out the signal. The generator produces a signal for damping the motor operation. The compass card, which indicates aircraft direction throughout 360 degrees, is read against a fixed lubber line at the top of the indicator.



Refer to the illustration and mark the statements below either True (T) or False (F).

_____1. The heading signal from the Electronic Control Amplifier goes to the synchrorotor.

_____2. The signal from the rotor is amplified to drive a motor generator.

_____3. The generator provides a voltage to null out the input signal.

_____4. The mechanical linkage repositions the synchrorotor and rotates the compass card to the new heading.

Answers to Frame 8: T 1. F 2. T 3. F 4.

Frame 10

The Horizontal Situation Indicator (HSI) is the pilot's directional indicating instrument. It is not a major component of the Auxiliary Flight Reference System (AFRS), but receives heading input signals from the AFRS in the event of a malfunction of the Inertial Bomb Nav System (IBNS) that serves as the primary signal source of the HSI. The HSI also receives heading inputs from the AFRS if the Flight Instrument Reference Switch (Prim-Aux switch), in the cockpit, is in the "AUX" position. Study the block diagram on page 13 of HO-403. The arrows show the direction of signal flow. The direction the aircraft is flying is read against the fixed lubber line (top of the indicator), and the miniature aircraft symbol (in the center of the indicator). A rotating compass card displays the degree of aircraft heading. The internal circuitry to drive the HSI compass card, is the same as that covered in the BDHI operation.

1. Complete the following statements by underlining the correct answer(s).

a. The (IBNS, AFRS) is the primary source of heading information to the HSI.

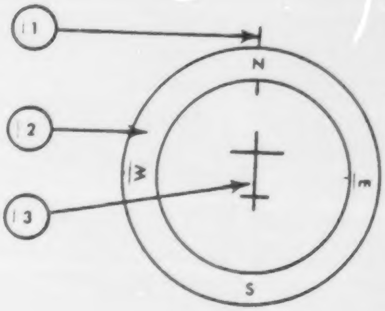
b. When the Flight Instrument Reference Switch is in (PRIM, AUX), heading inputs to the HSI are from the Auxiliary Flight Reference System.

2. Identify the following units by placing the number from the diagram in the space provided on the left.

_____a. compass card

_____b. miniature aircraft symbol

_____c. lubber line



Answers to Frame 9: F 1. T 2. F 3. T 4.

Frame 11

The last indicator to be covered that displays aircraft direction to the pilot is the Attitude Director Indicator (ADI). Like the HSI it is not a major component of the AFRS, but does receive heading information from the AFRS when the Flight Instrument Reference Switch is in the AUX position. Heading information is displayed on the sphere (refer to picture below) and is read against the miniature aircraft symbol. Under normal operating conditions the primary source of heading information to the ADI is the IBNS, but in event of an IBNS malfunction, signals to the ADI will be received from the AFRS. With the IBNS supplying heading information to the ADI and HSI and the AFRS supplying heading information to the BDHI, the pilot has two systems to use as a cross check.

Figure A below shows the aircraft flying north with the ADI indicating north. Figure B shows the aircraft flying 30 degrees and the ADI indicating 30 degrees.

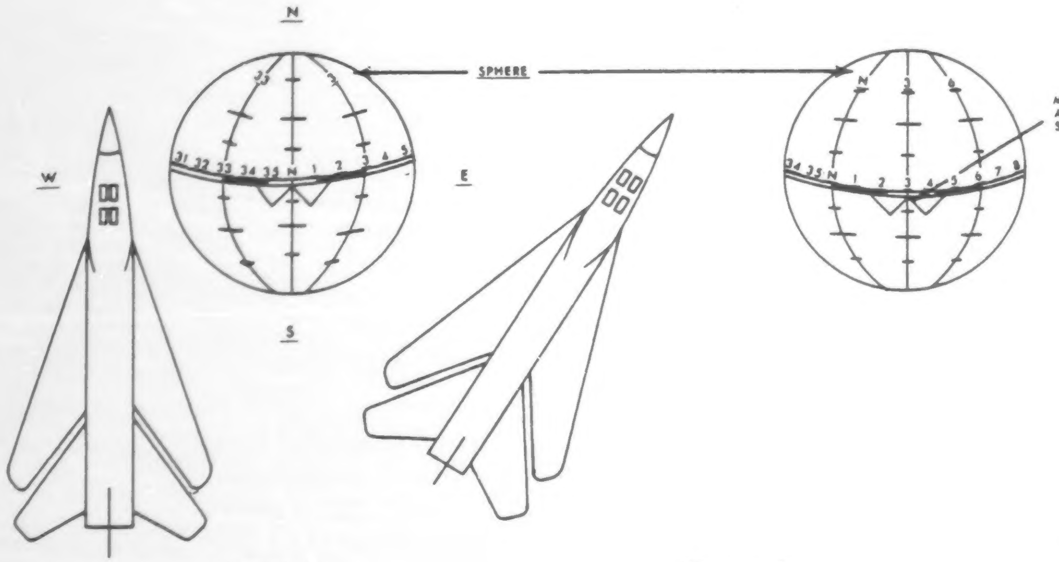


Figure A

Figure B

1725

Complete the following statements by underlining the correct answer.

1. The (IBNS, AFRS) is the primary signal source to the ADI.

2. The ADI (is, is not) a major component of the Auxiliary Flight Reference System.

3. Heading information is supplied to the ADI, by the AFRS, when the Flight Instrument Reference Switch is in the (PRIM, AUX) position.

Answers to Frame 10:

1. a. IBNS

   b. AUX

2. a. 2

   b. 3

   c. 1

Frame 12

Before covering the operation of the system in each mode, let's consider the purpose or function of each compass system controller selector switch position. The Slaved position is the normal operating mode. It is selected when the aircraft is flying in an area where the earth's magnetic lines of force are parallel to the earth. In this mode the remote compass transmitter is used to correct the gyro for apparent drift. This makes the gyro output a gyro stabilized magnetic heading signal. If for some reason the DG fails or its ouput signal is unreliable, the Compass (Comp) position is selected. In this mode the gyro heading signal is disconnected and the remote compass transmitter is the sole heading reference. In regions of weak or unreliable earth's magnetic field (such as above 70 degrees latitude or within 1000 miles of the magnetic pole) the DG position is selected. During the DG or free-gyro mode, the displacement gyro is supplying the reference to changes in aircraft heading.

Match the correct mode of operation in Column I to the purpose of each mode in Column II.

Column I		Column II
a. DG	_____1.	Used under normal flight conditions.
b. Slaved	_____2.	Used as an emergency mode.
c. Comp	_____3.	Used near the equator.
	_____4.	Selected when gyro output is unreliable.
	_____5.	Selected above 70 degrees latitude.
	_____6.	Does not use the Compass Xmtr as a reference.
	_____7.	Is a gyro stabilized magnetic compass mode.

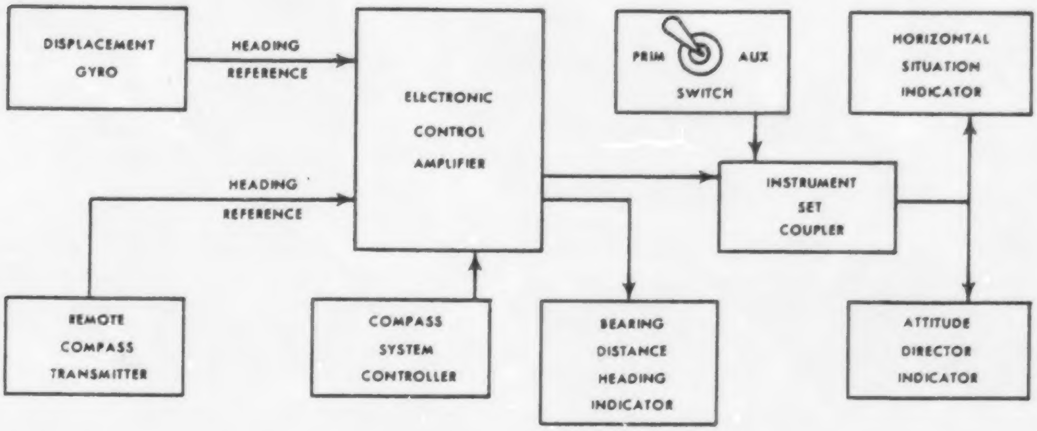
Answers to Frame 11: 1. IBNS 2. is not 3. AUX

1727

Frame 13

At this point you should know what the Gyro Stabilized Compass System does and what components it consists of. The Directional Gyro is a stabilized reference that uses synchros to electrically sense the degree of aircraft turn. The Remote Compass Transmitter senses the north-south direction of the earth's magnetic field and produces an electrical heading (direction) output signal. The Electronic Control Amplifier receives both signals. These signals are amplified by the ECA and the position of the Mode Selector Switch on the Compass System Controller determines what the ECA does with the signals. The outputs from the ECA are sent directly to the BDHI and to the HSI and ADI if the Flight Instrument Reference switch is positioned to "AUX" or a malfunction occurs in the IBNS.

Study the block diagram below to determine signal flow throughout the system.


DISPLACEMENT GYRO
HEADING REFERENCE
ELECTRONIC CONTROL AMPLIFIER
PRIM
AUX
SWITCH
HORIZONTAL SITUATION INDICATOR
HEADING REFERENCE
INSTRUMENT SET COUPLER
REMOTE COMPASS TRANSMITTER
COMPASS SYSTEM CONTROLLER
BEARING DISTANCE HEADING INDICATOR
ATTITUDE DIRECTOR INDICATOR

Answers to Frame 12:

b 1.
c 2.
b 3.
c 4.
a 5.
a 6.
b 7.

1300

Frame 14

Match the components and subcomponents in Column II to the statements in Column I.

Column I	Column II
_____1. Produces heading reference signals.	a. Compass System Controller
_____2. Amplifies heading signals before they are applied to the indicators.	b. Displacement Gyro Package
_____3. Provides a means for controlling and monitoring the compass system.	c. Electronic Control Amplifier
_____4. Contains vertically and horizontally mounted gyros.	d. Remote Compass Transmitter
_____5. Is the system's magnetic direction sensing unit.	e. Bearing Distance Heading Indicator
_____6. Receives heading signals directly from the Electronic Control Amplifier.	
_____7. Senses the direction of the earth's magnetic field.	

Complete the following statements by underlining the correct answers.

8. The directional gyro spin axis is maintained (perpendicular, horizontal) to the earth.

9. An unlevel condition of the Directional Gyro is sensed by (electrolytic switches, a leveling pick-off sensor).

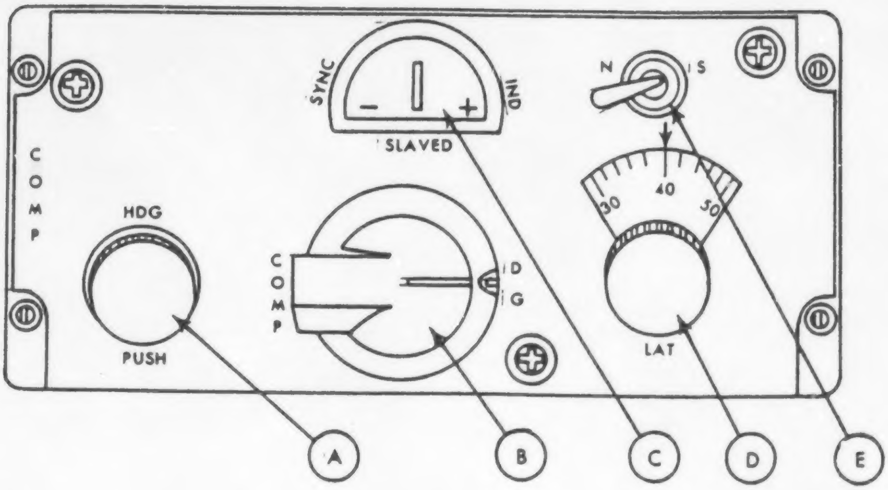
10. When the aircraft turns, the directional gyro (holds a fixed position, turns with the aircraft).

11. Outputs from the Displacement Gyro Package are transmitted (directly to the indicators, to the Electronic Control Amplifiers).

12. Outputs from the Remote Compass transmitter are applied directly to the (displacement gyro package, electronic control amplifier).

1729

Match the items in the illustration to the terms or statements below. Letters may be used more than once.



_____13. Heading Set Knob

_____14. Hemisphere Selector Knob

_____15. Latitude Correction Knob

_____16. Mode Selector Switch

_____17. Synchronization Indicator

_____18. Placed in the S position when the aircraft is flying below the equator.

_____19. Set to a particular mode of operation.

_____20. Set to the latitude the aircraft is flying.

_____21. Tells when the indicators are reading correctly.

_____22. Used to rotate the compass card to a desired setting.

Match the mode of operation in Column II to the purpose or condition of each mode in Column I.

Column I

_____23. Does not use the compass transmitter as a reference.

_____24. Is a gyro stabilized magnetic compass mode.

_____25. Selected above 70 degrees latitude.

_____26. Selected when the gyro output is unreliable.

_____27. Used as an emergency mode.

_____28. Used near the equator.

_____29. Used under normal flight conditions.

Column II

a. Comp

b. DG

c. Slaved

Answers to Frame 14: __d__1. __c__2. __a__3. __b__4. __d__5.
__e__6. __d__7. 8. horizontal 9. a leveling pick-off sensor
10. holds a fixed position 11. to the Electronic Control Amplifier
12. electronic control amplifier __a__13. __e__14. __d__15.
__b__16. __c__17. __e__18. __b__19. __d__20. __c__21. __a__22.
__b__23. __c__24. __b__25. __a__26. __a__27. __c__28. __c__29.

If you have missed any questions in Frame 14, return to the appropriate frame to insure a complete knowledge of the materials presented in section B. After you have reviewed this section, ask your instructor for the Appraisal for Section B.

1731

SECTION C - GYRO STABILIZED MAGNETIC COMPASS SYSTEM

Section C is designed to give you a better understanding of the compass system operation and prepare you to use the wiring diagrams for troubleshooting the system. Each mode of operation in the compass system will be covered. The diagrams used for a particular frame have been simplified so that only the circuitry for the mode of operation being explained is shown.

PART I - Modes of Operation

SPECIAL INSTRUCTIONS

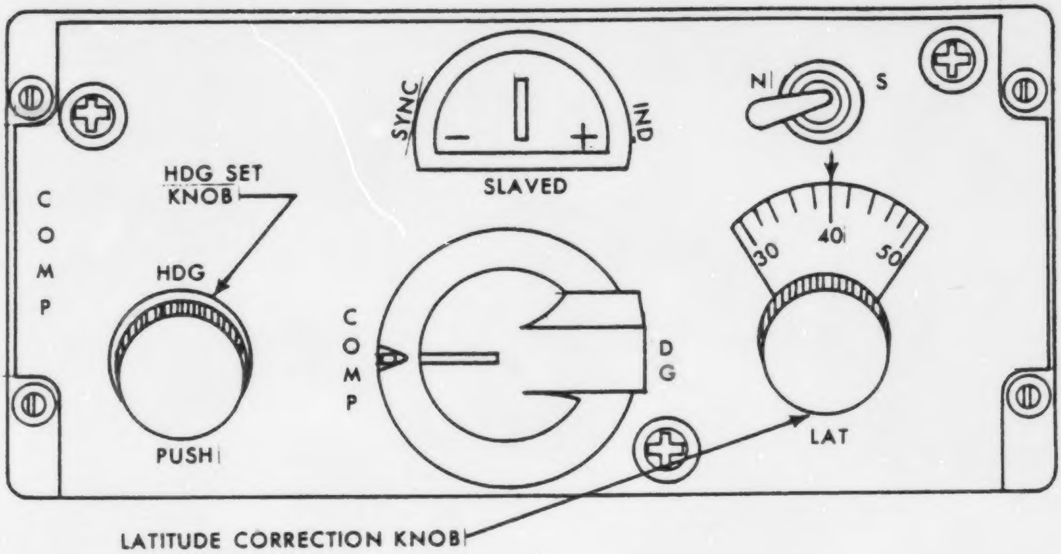
Because of the importance of material in each frame, you must have a thorough understanding of each frame before you proceed to the next frame. Read the frames again whenever you feel that you do not have a complete understanding of the material presented.

Illustrations and diagrams from pages 14 through 20 of HO-403 will be used with this section of this text.

1804

Frame 1 1732

An understanding of system operation by modes is necessary to aid in learning operational checks and troubleshooting procedures. The first mode that will be covered is the "DG" mode. This mode is used above 70 degrees latitude where the earth's magnetic lines of force are not parallel to the earth. Normally the Remote Compass Transmitter furnishes a signal to correct for gyro drift. But in the "DG" mode, another method must be used because the Compass Transmitter signal is not reliable above 70 degrees latitude. Remember, the amount of drift varies with the latitude the aircraft is flying. (0 drift at the equator, maximum drift at the poles.) If the gyro drift is not corrected, the heading reference signal to the indicators would be in error. The apparent drift correction used in the "DG" mode is set by the "Latitude Correction Knob" on the Compass System Controller. Refer to the drawing below to determine the location of the Latitude Control Knob.



Complete the statements below by underlining the correct answer.

1. The DG mode is used near the (equator - poles).

2. The degree of gyro drift varies with the (latitude - longitude) the aircraft is flying.

3. Above 70 degrees latitude, the remote compass transmitter (can - cannot) be used as a reference.

4. In the DG mode, gyro drift is controlled by setting the (compass transmitter - latitude control knob).

5. The remote compass transmitter is used as a heading reference when the earth's magnetic field is (parallel - perpendicular) to the earth.

1805

1733

Frame 2

Refer to the schematic on page 14 of HO-403. Notice that the Mode Selector Switch on the Compass Controller is in the DG position. The Hemisphere Selector Switch is in the "N" position, indicating that the aircraft would be flying in the northern hemisphere. Since apparent drift is equal and opposite in the southern hemisphere, the "S" position would be selected when crossing the equator. The "NS" Hemisphere Selector Switch establishes the polarity of the drift correction signal applied to the Slaving Torquer (ST) in the displacement gyro. Visually trace the correction signal from the Latitude Control Knob Potentiometer to the Slaving Torquer (ST). This signal is a predetermined value depending on the setting of the Latitude Control Knob. The voltage from the Latitude Control Knob Potentiometer is applied to the ST, causing the gyro to precess at a rate equal and opposite to the rate of apparent drift. If the gyro is precessed equal and opposite to the rate of apparent drift, the gyro will hold a fixed position.

Referring to the schematic on page 14 of HO-403, complete the statements below by underlining the correct answer.

1. Under conditions shown, the Mode Selector Switch is in the (Comp, Slave, DG) position.

2. The Hemisphere Selector Switch is set to the (North, South) hemisphere.

3. The Latitude Selector Control has been set to (60, 70, 80, 90) degrees.

4. The "Comp" relay in the Electronic Control Amplifier is (energized, deenergized).

5. The correction voltage to the Slave Torquer originates at the (Mode Selector, Latitude Control Potentiometer, Directional Indicator).

6. Gyro drift is cancelled by causing the Slave Torquer to precess the DG in the (same direction, opposite direction) of gyro drift.

7. The unit that reverses the polarity of the Slave Torquer input is the (Mode Selector, Hemisphere Selector Switch, Latitude Control Knob).

Answers to Frame 1: 1. Poles 2. Latitude 3. cannot

4. Latitude Control Knob 5. Parallel

1806

Now that we have the DG holding a fixed position, the heading synchro (Hdg CX) in the displacement gyro will produce an accurate heading output signal whenever the aircraft changes direction. This signal is transmitted to the Electronic Control Amplifier (ECA) where it is processed and amplified before being sent to the directional indicators. Referring to page 14 of HO-403, visually trace the signal flow from the HDG CX in the displacement gyro, to the ECA and apply it through the contacts of the COMP relay to the synchro differential (CDX). From the rotor of the CDX, the signal goes to the control transformer of the "Heading Follow-Up Servo Module." The module consists of a closed servoloop. Signals applied to the CT are amplified and applied to the motor generator (MG). The MG mechanically repositions the rotors of the CT and TX (heading output transmitter) through mechanical linkage. Repositioning the CT rotor nulls the input signal. Repositioning the TX rotor produces a heading output signal which is transmitted to the directional indicator where the signal is applied to a closed servoloop in the indicator. All indicator servoloop operation will be the same as was previously explained in the operation of the BDHI servoloop in Frame 8 of Section "B".

Complete the following statements by underlining the correct answer.

1. The input to the indicator is received directly from the (Compass Controller, Displacement Gyro, Electronic Control Amplifier).

2. Any change in aircraft heading is sensed by the (Hdg CX, Comp Relay).

3. Heading outputs from the electronic control amplifier are produced in the (CDX, TX, CT).

4. The heading signal is processed and amplified by the (Displacement Gyro, Compass Controller, Electronic Control Amplifier).

Answers to Frame 2: 1. DG 2. North 3. 70 4. Deenergized

5. Latitude Control Potentiometer 6. Opposite direction

7. Hemisphere Selector Switch

1735

Frame 4

When applying power to the system, the Directional Gyro is leveled to a horizontal spin axis, but not aligned to a particular directional heading. Because of this, the system must be referenced to a known heading. In the "Slave" mode, the direction sensing component (Remote Compass Transmitter) references the gyro; but in the "DG" mode, the Compass Transmitter is not used. Therefore, directional gyro referencing is done by the pilot. To accomplish this, the pilot must know the direction the aircraft is heading. On the ground, he can align the aircraft, to the center line of a runway. He now uses the "Heading Set Knob" on the Compass System Controller (refer to the drawing in Frame 1) to electrically drive the indicator compass card until it reads the correct aircraft heading. Now that the compass card is indicating correctly, any change in aircraft direction, sensed by the directional gyro HDG CX results in an equal change on the compass card. Thus, the correct heading indications are maintained during aircraft turns.

Complete the statements below by underlining the correct answer.

1. In the "DG" mode, the system is aligned to the correct magnetic heading by the (Remote Compass Transmitter, pilot).

2. Changes in the directional heading of the aircraft are sensed by the (directional gyro HDG CX, Latitude Correction Circuit).

Answers to Frame 3:
1. Electronic Control Amplifier
2. HDG CX.
3. TX.
4. Electronic Control Amplifier.

1808

To aid in understanding the "Hdg Set" operation, refer to the schematic on page 15 of HO-403. On the Compass System Controller you will find the "Hdg Set Control" which controls a switch and the wiper arm of a potentiometer. Pushing on the control closes the switch, to complete (as shown) the ground circuit to energize the "Hdg Set" relay in the ECA. This relay, in turn, provides fixed phase voltage to the motor generator in the "Hdg Set Servo Module." Turning the "Hdg Set Control" provides a signal from the potentiometer wiper arm to the "Hdg Set Servo Module." As the Hdg Set motor generator operates, it will mechanically reposition the stator of the synchro differential (CDX). This, in turn, produces a signal output which is applied to the Control Transformer (CT) in the "Heading Followup Servo Module." As the motor generator in the Followup Servo operates, it mechanically repositions the stator of the CT and rotor of the Heading Output Transmitter (TX). Repositioning the TX rotor produces an output signal which causes the compass card to be driven to the desired heading. Releasing the "Hdg Set Knob" removes the ground from the "Hdg Set" relay, returning the system to the normal "DG" mode of operation.

Using the schematic on page 15 of HO-403, underline the answer to the following questions and complete the tasks described.

1. During alignment of the system, the synchro differential (CDX) is (electrically, mechanically) controlled.

2. Amplifier outputs are applied directly to (motors, generators, synchros).

3. Inputs to the "Hdg Set Servo Module" are from the (TX, Hdg Followup Servo Module, Hdg Set Control Knob Pot.).

4. Pushing on the "Hdg Set Control Knob" (closes, opens) the Hdg Set Relay circuit to ground.

5. Using a red pencil, trace out the circuit which is energized by pushing the Hdg Set Control Knob.

6. Using a blue pencil, trace the Hdg Set circuit signal from the potentiometer through the "Hdg Set Module" to the stator of the CDX.

7. Using a green pencil, trace from the rotor of the CDX to the CT. From the rotor of the CT, trace through the remaining Followup Servo showing what is mechanically operated by the motor.

8. Using a brown pencil, trace the Hdg output from the stator of the TX through the indicator Servoloop to operate the compass card.

Answers to Frame 4: 1. Pilot 2. directional gyro HDG CX

Frame 6

The schematic on page 16 of HO-403 shows the system in the DG mode, including the circuitry for "Hdg Set" operation. Using this schematic, match the units in Column II to the statements in Column I.

Column I

_____1. Provides proper polarity for the drift correction signal.

_____2. Electrically senses any change in aircraft heading.

_____3. Provides the correct voltage to the torquer for a particular latitude the aircraft is flying.

_____4. Provides a visual indication of directional heading.

_____5. Receives inputs from the HDG Set Control Potentiometer.

_____6. Mechanically repositions the rotor of the TX to produce a heading output to the directional indicator.

_____7. Holds a fixed position to provide directional referencing

_____8. Is mechanically controlled by the "Hdg Set Servo Motor."

_____9. Is energized when the Hdg Set Knob is depressed.

____10. Applies a force to the gyro causing controlled precession to eliminate drift.

Column II

a. Directional Indicator

b. CDX

c. Hemisphere Selector Switch

d. Latitude Control Knob

e. Hdg Followup Servo Module

f. Mode Selector

g. "Comp" relay

h. "Hdg Set" relay

i. Directional Gyro

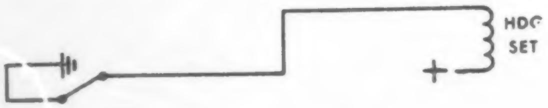
j. Slave Torquer

k. Hdg Set Servo Module

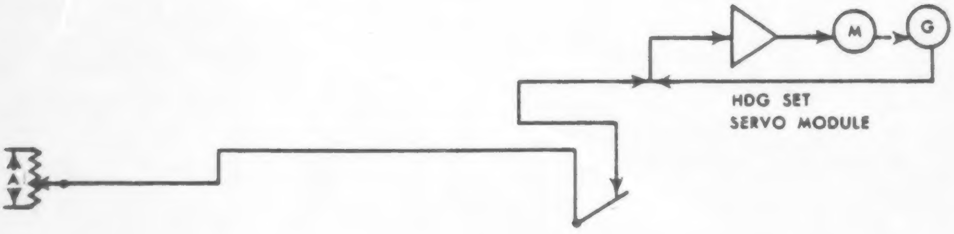
l. Hdg CX

Answers to Frame 5:
1. mechanically controlled
2. motors
3. Hdg Set Control Knob Pot.
4. closes

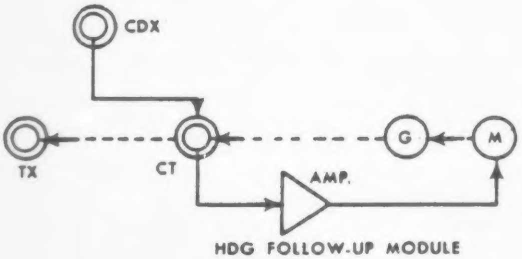
5.



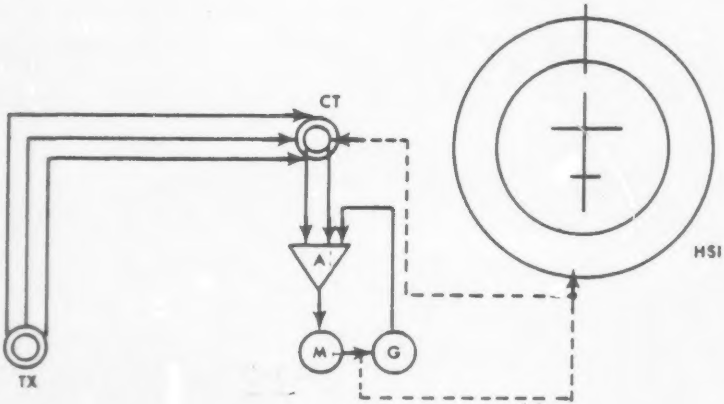
6.


A
M
G
HDG SET
SERVO MODULE

7.


CDX
TX
CT
G
M
AMP.
HDG FOLLOW-UP MODULE

8.


CT
A
M
G
TX
HSI

Frame 7

Before learning the operation of the system in the "Slaved Mode," return to page 42, Section B, Frame 1, and reread the explanation of a Gyro Stabilized Magnetic Compass.

We will first consider the normal operation of the system in the "Slaved Mode." By this, we mean that the directional indicators are indicating correct magnetic heading. Whenever the aircraft turns, the output from the gyro package causes the indicator dial to reposition to the new magnetic heading. Refer to the schematic on page 17 of HO-403 and visually trace the output from the directional Gyro Hdg CX to the Hdg Followup Servo. From the rotor of the CT, the signal is amplified to operate the motor generator which mechanically repositions the rotor of the Heading Output Transmitter (TX). From the stators of the TX, the signal is sent to the indicator to position the compass card to the aircraft's magnetic heading.

Referring to the schematic on page 17 of HO-403, underline the word or phrase that completes the statements below.

1. The Mode Selector Switch is in the (Comp, Slaved, DG) position.

2. The Slave Relay is (energized, deenergized).

3. Whenever the aircraft turns, heading change is sensed at the (CDX, CT, Hdg CX).

Answers to Frame 6: 1. c 2. l 3. d 4. a 5. k

6. e 7. i 8. b 9. h 10. j

Refer to the schematic on page 17 of HO-403. During operation in the "Slaved Mode" with the Directional Indicators showing the correct magnetic heading, the input to the Transolver (CT-RES) is electrically the same as the Heading Output Transmitter (TX) output. Visually trace the magnetic heading output sensed by the Remote Compass Transmitter to the stators of the CT-RES. Visually trace the output from the rotor of the Heading CX in the Displacement Gyro through the ECA to the TX. The output of the TX is the magnetic heading which causes the directional indicator to visually indicate magnetic headings. When the input to the CT-RES and output of the TX are electrically the same, we can say that the compass system is synchronized or in electrical alignment. At this time, there will be no output from the rotor of the transolver (CT-RES). In other words, the CT-RES is at null. Referring to the Compass System Controller, notice the Sync Indicator. Visually trace from the rotor of the CT-RES through the SLAVE relay contacts back to the Sync Indicator. When the Sync Indicator pointer is centered, the system is synchronized.

Mark the statements below TRUE (T) or FALSE(F).

1. _____ The system is said to be synchronized when magnetic heading sensed by the Transmitter is electrically the same as TX output from the ECA.

2. _____ Outputs from the TX are applied to the Slaving Torquer.

3. _____ When the sync indicator deflects left or right, the system is synchronized.

4. _____ The Hdg Followup Servo motor generator mechanically controls the position of the TX and CT-RES rotors.

Answers to Frame 7: 1. Slave 2. Energized 3. Hdg CX

Frame 9

Synchronization is the electrical alignment of the compass system. Now we will consider what happens when the directional gyro drifts causing the system to be out of synchronization. Referring to the schematic on page 17 of HO-403, consider that the system is in electrical alignment. The aircraft is flying north, therefore, the Remote Compass Transmitter is sensing north; the directional indicator is reading north and the sync indicator is centered. Now when the gyro drifts, the rotor of the Hdg CX is displaced the same degree that the gyro has drifted, resulting in a signal change (output) from the displacement gyro. Visually trace the signal output to the Heading Followup Servo Module in the ECA. The servo motor mechanically repositions the rotors of the control transformer (CT), Hdg Output Transmitter (TX), and Transolver (CT-RES). The resulting output from the stators of the TX is an erroneous signal to the directional indicator, causing it to read something other than north while the aircraft is still flying north.

Mark the statements below TRUE (T) or FALSE (F).

1. _____ The sync indicator is centered whenever the system is synchronized.

2. _____ The Followup Servo Motor will operate if the gyro drifts.

3. _____ The Followup Servo Motor repositions only the CT rotor.

4. _____ Gyro drift does not effect the indicator readings.

Answers to Frame 8: 1. T 2. F 3. F 4. T

1742

Referring again to the schematic on page 17 of HO-403, when the Gyro drifted, an output from the HDG CX in the Displacement Gyro caused the Hdg Followup Servo to mechanically reposition the rotors of the CT, TX, and CT-RES. Repositioning the rotor of the CT nulled out the input signal, while repositioning the rotor of the TX produced an erroneous signal to the Indicator. Repositioning the rotor of the CT-RES causes it to be out of null. (The system is no longer synchronized.) Visually trace the output from the rotor of the CT-RES to the Sync Indicator and to the Slave Torquer (ST). The pointer of the Sync Indicator deflects from its center position showing that the system is no longer synchronized. At the same time, the signal from the CT-RES is applied to the Slave Torquer causing the Gyro to precess in the opposite direction that it had drifted. As the Gyro is being precessed back, the rotor of the Hdg Transmitter CX is also turned in the opposite direction, resulting in another heading output (at this time being a corrected output). Visually trace back through the circuit to the Hdg Followup Servo Motor which mechanically repositions the rotors of the CT, TX, and CT-RES. Repositioning the TX rotor transmits a corrected magnetic heading output to the Indicators, and repositioning the rotor of the CT-RES nulls its output signal. When the CT-RES is nulled, the Torquer ceases to operate and the Sync Indicator is once again centered.

NO RESPONSE REQUIRED

Answers to Frame 9: 1. T 2. T 3. F 4. F

1743

Frame 11

We know that the Remote Compass Transmitter senses the earth's magnetic field to produce a signal which keeps the DG from drifting. The same signal produced by the Transmitter is also used to initially synchronize the system. Keep in mind that when power is first applied, the Directional Gyro is allowed to remain at the position to which it is leveled. Allowing the Gyro to remain at that random position, the Indicator must be servoed to the correct magnetic heading sensed by the Compass Transmitter. When this is accomplished, the system will be in electrical alignment. In the "Slave Mode" of operation, initial synchronization with the Compass Transmitter Heading is obtained by pushing and holding the Hdg Knob until the Sync Indicator becomes centered. Refer to the schematic on page 18 of HO-403 to become familiar with the system conditions during synchronization when in the "Slaved Mode," and the Hdg Set Knob is depressed.

Referring to the schematic on page 18 of HO-403, answer the following questions.

1. a. What relay is energized when the Hdg Set Knob is depressed?

b. This relay supplies power to which module? (Hdg Set Servo Module, Hdg Followup Servo Module).

c. With this relay energized, signal input to the above selected module is from the (Directional Gyro, Hdg CX, Remote Compass Transmitter).

2. a. With the mode Selector Switch in the "Slave" position, a ground is applied to which relay? (Slave, Hdg Set)

b. With this relay energized, the signal from the Compass Transmitter is applied to which module? (Hdg Set, Hdg Followup)

3. a. Under the condition shown, what heading is indicated by the Directional Indicator?

b. Under conditions shown, what is the correct magnetic heading?

4. What magnetic heading is the Remote Compass Transmitter sensing?

5. Under the conditions shown on the schematic, the system is (synchronized, out of synchronization).

1816

Frame 12

For a better understanding of synchronization, refer to the schematic on page 18 of HO-403 and visually follow the circuits as explained. The conditions that cause the system to be out of synchronization are: the Indicator is reading 045 degrees, and the Compass Transmitter is sensing 000 degrees. When the Indicator reads the direction sensed by the Transmitter, the system will be synchronized. Trace the output from the Compass Transmitter to the Hdg Set Module and the Sync Indicator. The Sync Indicator deflects from its center position to show that the system is out of electrical alignment. The signal to the Hdg Set Module causes the stator of the CDX to be repositioned. Trace the output from the rotor of the CDX through the Hdg Follow-up Module which mechanically repositions the rotors of the CT, TX, and CT-RES. Repositioning the CT rotor nulls out the signal. Repositioning the rotor of the TX causes its output to be the same magnetic heading as sensed by the Transmitter, therefore, the Indicator will now read 000 (N). Repositioning the CT-RES rotor nulls out the CT-RES so it no longer has an output, therefore, the Sync Indicator centers and the Hdg Set Servo stops operating. Now the system is synchronized and the position of the Gyro can now be used as a magnetic reference.

Mark the statements below TRUE (T) or FALSE (F).

_____1. During initial synchronization, the DG is precessed to a northerly direction.

_____2. During initial synchronization, the Indicator is servoed to the correct magnetic heading.

_____3. When the system is synchronized, the CT-RES is out of null.

_____4. The Sync Indicator is centered when the system is synchronized.

_____5. A signal from the TX controls the Sync Indicator.

_____6. The output of the Compass Transmitter is applied to the Hdg Set Module.

Answers to Frame 11:

1. a. Hdg Set
   b. Hdg Set Module
   c. Remote Compass Transmitter
2. a. Slave
   b. Hdg Set
3. a. 045 degrees
   b. 000 - North
4. 000 - North
5. Out of synchronization

1745

Frame 13

When the system is operating in either the "DG" or "Slaved" modes, the Directional Gyro is the reference which supplies information to the Indicators whenever the aircraft changes its heading (direction). With the Gyro referenced either manually in the "DG" mode or by the Remote Compass Transmitter in the "Slave" mode, its output represents accurate magnetic heading for Indicator operation. In event that the Gyro fails to operate, or its output is not accurate, the pilot will select the "Compass" mode of operation. In the "Compass" mode, the Remote Compass Transmitter is the sole heading reference. As the aircraft changes its heading, this change in direction is sensed by the Transmitter. This change in heading is electrically transmitted to the CT-RES and amplified in the Electronic Control Amplifier. The ECA output signal causes the Indicator compass card to drive to the new magnetic heading sensed by the Compass Transmitter. This circuitry is the same as explained during "initial synchronization" when in the "Slave" mode of operation.

Underline the correct answer in the following statements.

1. In the "DG" mode, Gyro referencing is accomplished (manually by the pilot, by the Remote Compass Transmitter).

2. In the "Slave" mode, Gyro referencing is accomplished (manually by the pilot, by the Remote Compass Transmitter).

3. The "Compass" mode is used (above 70° latitude, for normal operation, as an emergency mode).

4. In the "Compass" mode, heading changes are sensed by the (Remote Compass Transmitter, Directional Gyro).

5. In event of Gyro failure, the pilot will select the (DG, Comp, Slave) mode of operation.

Answers to Frame 12: 1. F 2. T 3. F 4. T

5. F 6. T

1818

The question that should be asked now is "Why not always use the Compass mode whenever the Remote Compass Transmitter can be used to supply magnetic heading to the Indicators without the use of a Directional Gyro?" First, consider how the Remote Compass Transmitter operates. The sensing unit (pick-up-coils) must be parallel to the earth so that the earth's magnetic lines of force are parallel to the pick-up-coils. The sensing unit is pendulously mounted so that it will remain parallel to the earth with up to 30 degrees aircraft roll (refer to the drawing on page 19 of HO-403). Whenever the aircraft banks (rolls) to turn, centrifugal force causes the sensing unit to seek a position parallel to the aircraft wings, rather than parallel to the earth. At this time the Transmitter will be producing erroneous output signals which would cause the Indicator to read incorrect magnetic heading. When the aircraft has completed its turn and is once again level, the Indicator reading will again be accurate. The system is more accurate with a Gyro providing stabilized signals, but when it cannot be used, the "Compass" mode provides sufficient accuracy until the aircraft can be landed and the malfunction repaired.

Study the drawings on page 19 of HO-403. Note the position of the sensing unit during level flight, bank without turns, and bank during turns.

Underline the correct answer that completes the following statements.

1. The Remote Compass Transmitter pick-up coils must be (parallel, perpendicular) to the earth's magnetic field to function properly.

2. The direction sensing unit will remain parallel to the earth with up to (30, 45, 60, 75) degrees of aircraft roll.

Answers to Frame 13:

1. Manually by the pilot
2. By the Remote Compass Transmitter 3.
3. As an emergency mode
4. Remote Compass Transmitter
5. Comp

1747

Frame 15

Now that we know when the "Compass" mode is used and why it is not used in place of the "Slaved" mode, we will refer to the schematic on page 20 of HO-403 to determine what conditions exist when the selector is placed in the "Compass" position. Looking at the Compass System Controller, you can see that the mode switch is in the "Compass" position, providing a ground to energize both the Hdg Set and Compass relays. The "Hdg Set Relay" is providing a path for the Compass Transmitter signal to be applied to the "Hdg Set Servo Module," at the same time providing fixed phase voltages to the motor generator. The "Compass Relay" has cut off the signal from the Directional Gyro. Because it is not used, it is not shown in this mode. The Compass Relay has also provided a ground to energize the "Slave Relay." The "Slave" relay is also providing a path for the Compass Transmitter signal to be applied to the "Hdg Set Servo Module." It also provides a path for the same signal to the "Sync" Indicator.

Refer to the schematic on page 20 of HO-403 to answer the following questions and to complete the tasks described.

1. a. In the Compass mode, what relays are energized directly by the Mode Selector Switch?

b. Using a red pencil, trace from the Mode Selector to these relays.

2. a. What relay is energized when the "Comp" relay is energized?

b. Using an orange pencil, trace the circuit from ground to this relay.

3. a. Using a blue pencil, trace the output from the Remote Compass Transmitter to the "Hdg Set Module."

b. What Synchrorotor is mechanically repositioned by the "Hdg Set Module?"

4. a. What Synchro produces the signal input to the "Heading Followup Module?"

b. Using a brown pencil, trace from this Synchro through the "Hdg Followup Servo," showing what is mechanically positioned.

5. Why is the rotor of the CT-RES positioned by the "Hdg Followup Servo?"

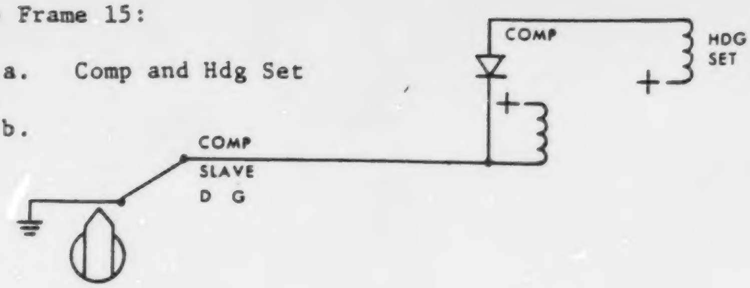
Answers to Frame 14: 1. parallel 2. 30

1820

Answers to Frame 15:

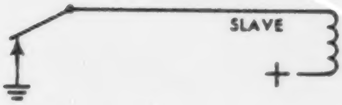
1. a. Comp and Hdg Set

b.

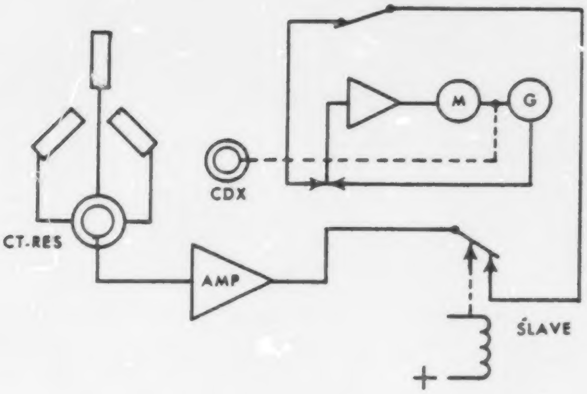

COMP
HDG SET
+
+
COMP
SLAVE
D G

2. a. Slave

b.



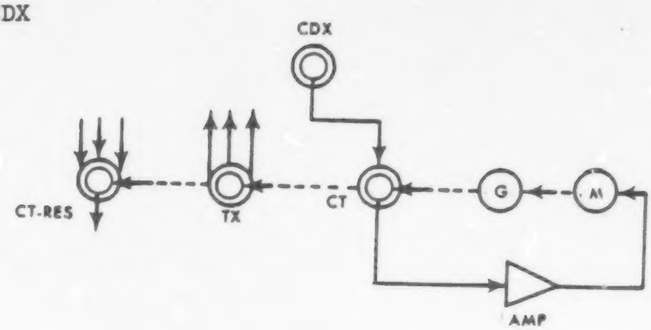
3. a.


M
G
CDX
CT-RES
AMP
SLAVE
+

b. CDX

4. a. CDX

b.


CDX
CT-RES
TX
CT
G
M
AMP

5. To null out the output signal when the system is synchronized.

1749

Frame 16

A. Using the diagrams on pages 21 through 23 in HO-403, complete the following statements by underlining the correct answer(s).

Note: All relays are shown deenergized with all contacts in their normal position with NO POWER on.

1. The Sync Indicator shows (Direction Gyro Leveling, Electrical Alignment of the system, Aircraft heading).

2. The (pilot, remote compass transmitter) accomplishes gyro referencing when in the SLAVE MODE.

3. Reversing the polarity of the latitude correction voltage is accomplished by repositioning the (Hdg Set Knob, Latitude control knob, N-S Hemisphere Switch).

4. Inputs to the Slave Torquer originate at the (Sync Indicator, Remote Compass Transmitter, Latitude Correction Potentiometer) when the Mode Selector switch is in the DG position.

5. The (Slave, HDG Set, Comp) relay(s) are energized when the mode selector is in the COMP position.

6. Aircraft turns are electrically sensed by the (HDG, CX, CDX, TX).

7. When in the Slave Mode, the (Slave, HDG Set, Comp) relay is energized.

8. When the HDG Set Knob is depressed, the (Slave, HDG Set, Comp) relay is energized.

9. Gyro drift is eliminated by the (Heading CX, Slave Torquer, Heading Followup Servo Module).

10. Turning the "HDG Set Control Knob" applies a voltage to the (HDG Followup Servo, HDG Set Servo) module.

B. Use page 21 of HO-403 to accomplish the tasks listed below.

Note: All relays are deenergized. Contacts are in the proper position for NO POWER applied to the system.

With the mode selector switch in the position shown (DG position).

1. Using a red pencil, show which switch is closed when the HDG Set switch is depressed by drawing the contact to the closed position.

2. Using a red pencil, trace from ground to the relay which is energized when the HDG Set Knob is depressed. Also draw the relay contacts to the closed position.

1822

3. Using a blue pencil, trace from the HDG set potentiometer to the Heading Set Servo Module. Also trace from the motor generator mechanical linkage to the CDX.

4. Using a brown pencil, trace the signal produced at the CDX to the Heading Followup Servo Module. Also trace the mechanical linkage to the TX.

C. Use page 22 of HO-403 to accomplish the tasks listed below.

Note: All relays are deenergized. Contacts are in the proper position for NO POWER applied to the system.

With the mode selector switch in the position shown (Slave position).

1. Using a red pencil, trace from ground to the relay(s) that will be energized when power is applied to the system. Also trace the relay contacts to the appropriate position for power on.

2. Use a blue pencil to trace the circuit which causes the sync indicator to operate.

3. Using a brown pencil, trace the remote compass transmitter output to the slave torquer.

4. Using a green pencil, trace the displacement gyro package, heading output signal to the Hdg Followup module. Also trace its mechanical motion to the TX and CT-RES.

D. Use page 23 of HO-403 to accomplish the tasks listed below.

Note: All relays are deenergized. Contacts are in the proper position for NO POWER applied to the system.

With the mode selector switch in the position shown (Comp position).

1. Using a red pencil, trace from ground to the relay(s) that will be energized when power is applied to the system, and trace the relay contacts to the appropriate position for power on.

2. Using a blue pencil, trace the output of the Remote Compass Transmitter to the Hdg Set Servo Module. Also trace through the amplifier and motor generator showing the mechanical output to the CDX.

3. Using a brown pencil, trace the heading output from the electronic control amplifier to the Directional Indicator. Also trace through the indicator servoloop to the compass card.

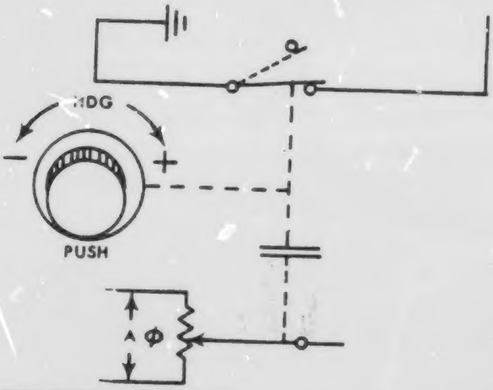
1751

Answers to Frame 16:

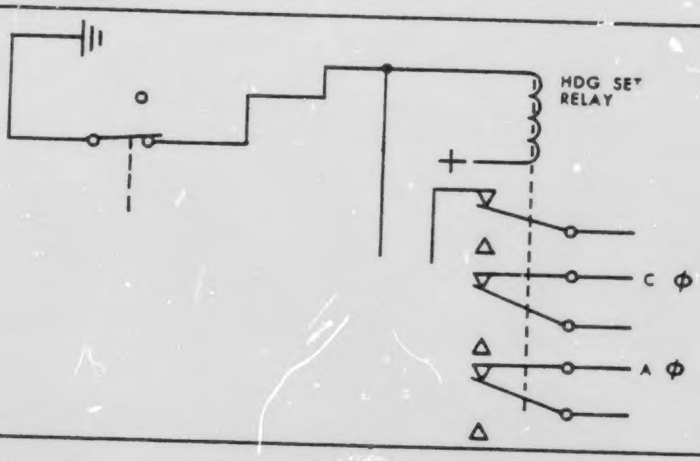
A.
1. Electrical Alignment of the system
2. Remote compass transmitter
3. N-S Hemisphere Switch
4. Latitude Correction Potentiometer
5. Slave, HDG Set, Compass
6. HDG CX
7. Slave
8. HDG Set
9. Slave torquer
10. HDG Set Servo

B.

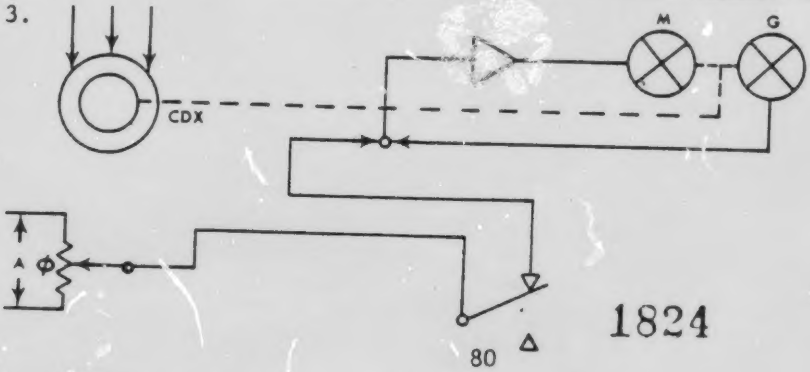
1.



2.

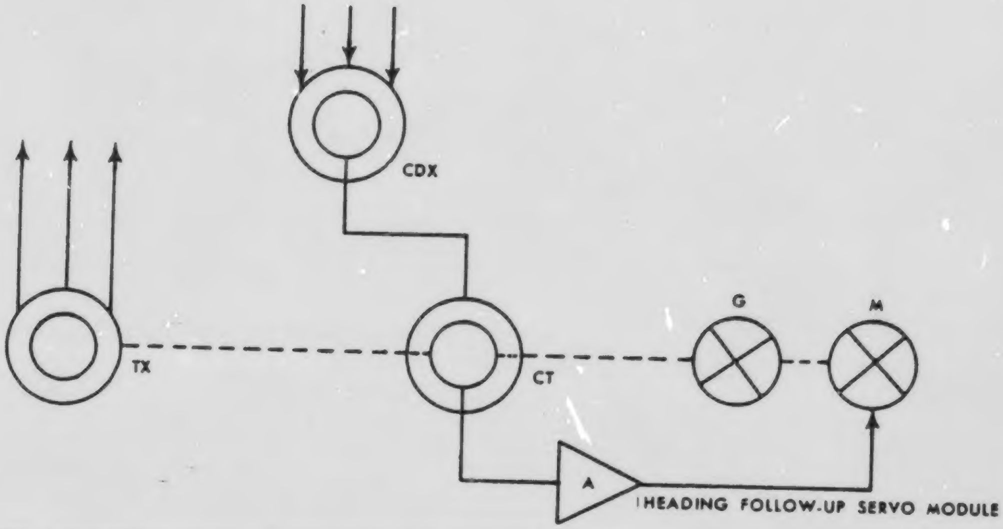

HDG SET
RELAY
+
C Φ
A Φ

3.



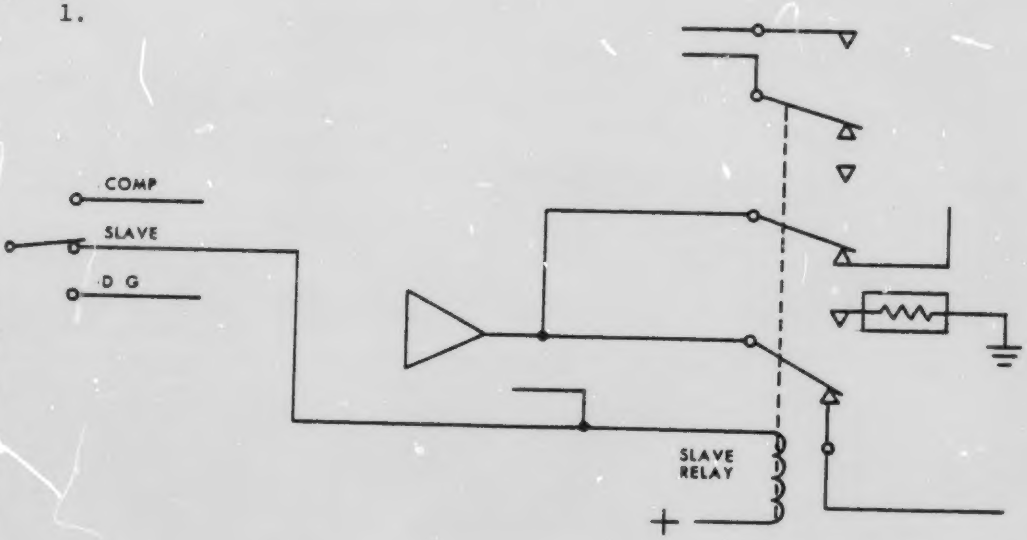
1752

4.


CDX
TX
CT
G
M
A
HEADING FOLLOW-UP SERVO MODULE

C.

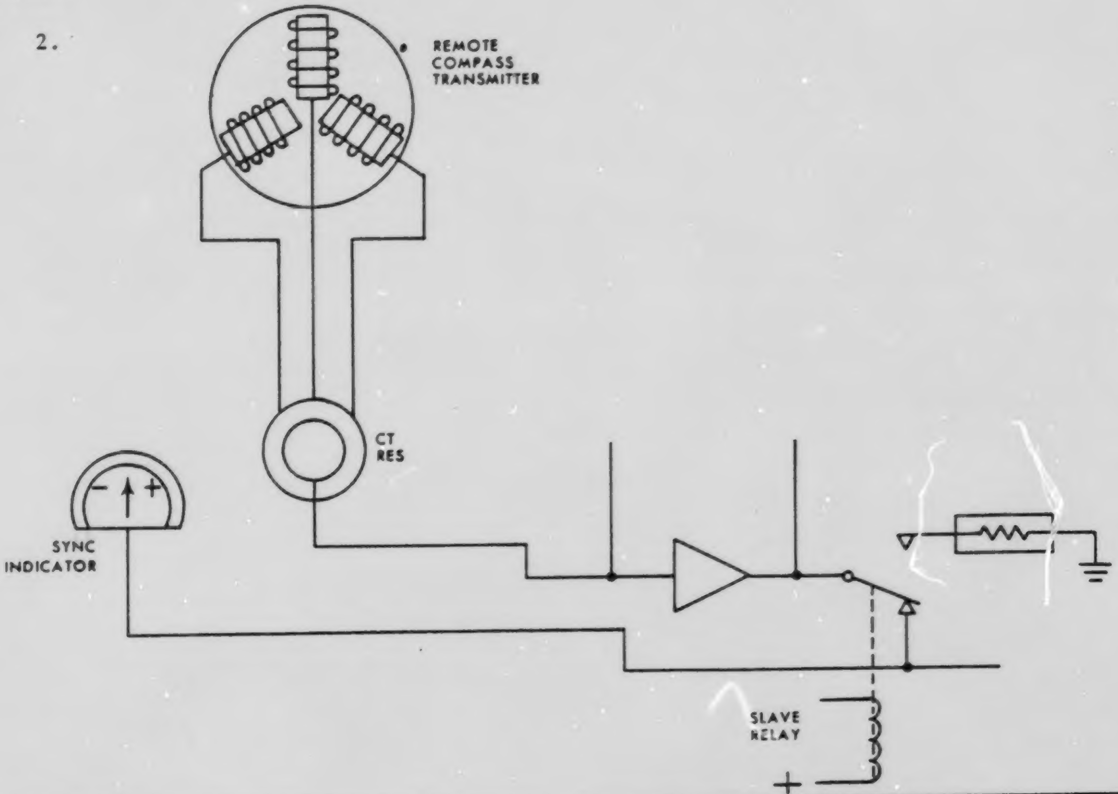
1.


COMP
SLAVE
D G
SLAVE RELAY
+

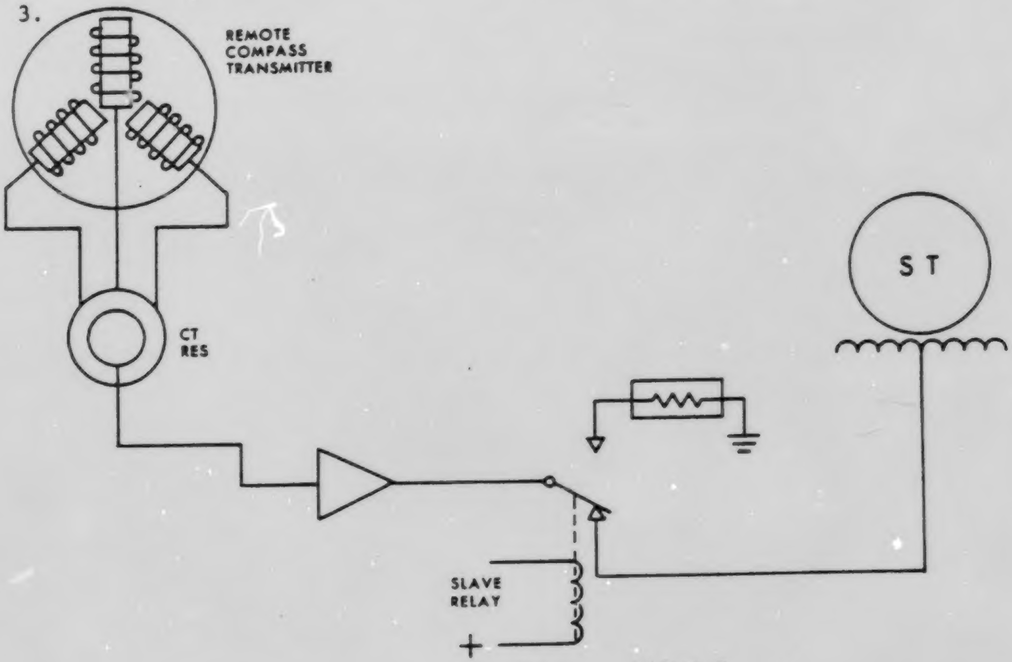
1753

C.

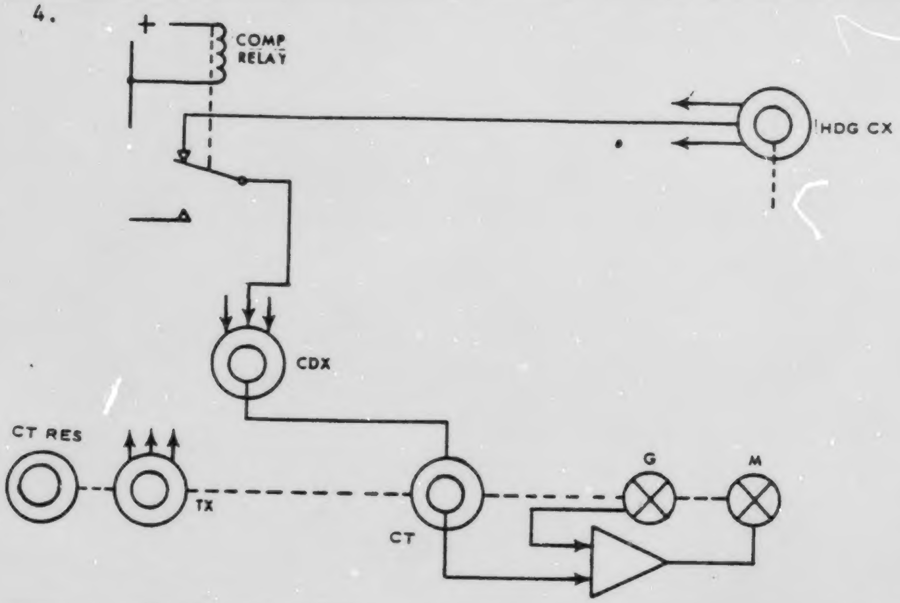
2.


REMOTE
COMPASS
TRANSMITTER
CT
RES
SYNC
INDICATOR
SLAVE
RELAY
+

3.

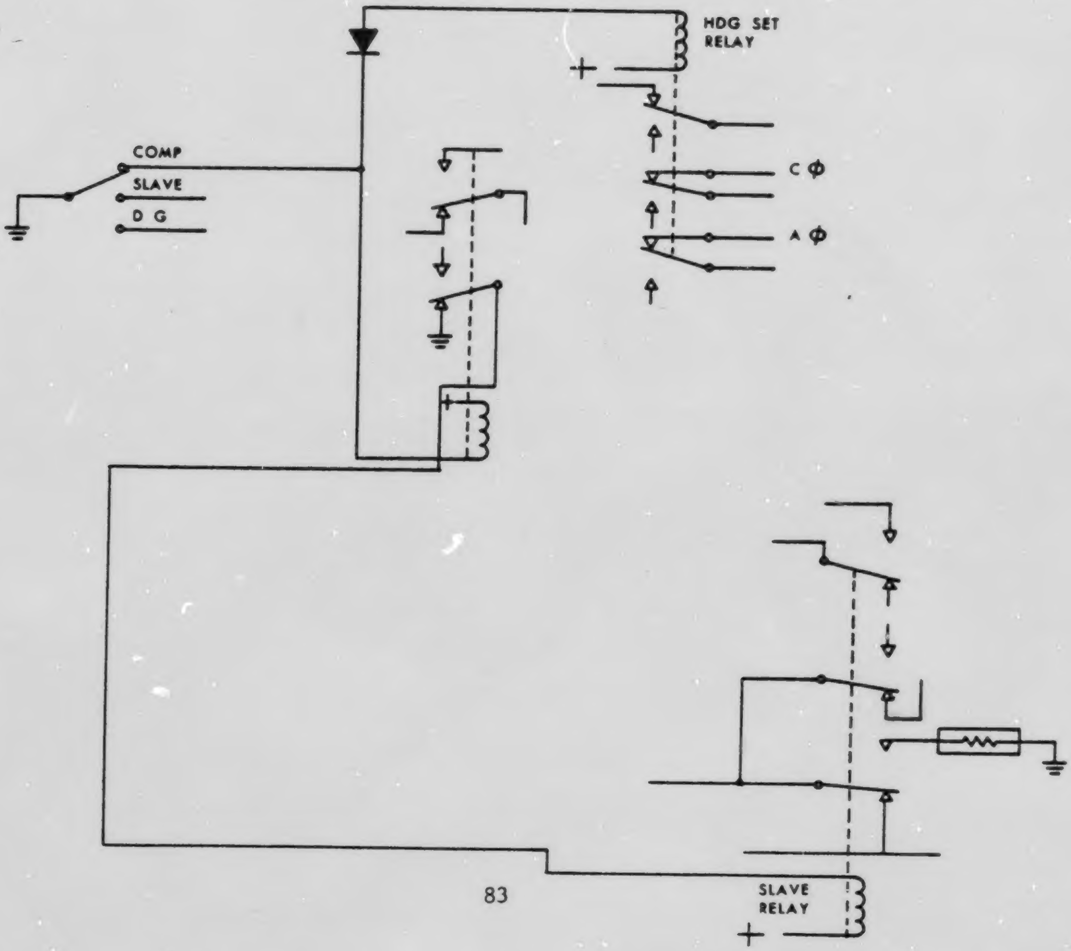

REMOTE
COMPASS
TRANSMITTER
CT
RES
S T
SLAVE
RELAY
+

4.


+
COMP RELAY
HDG CX
CDX
CT RES
TX
CT
G
M

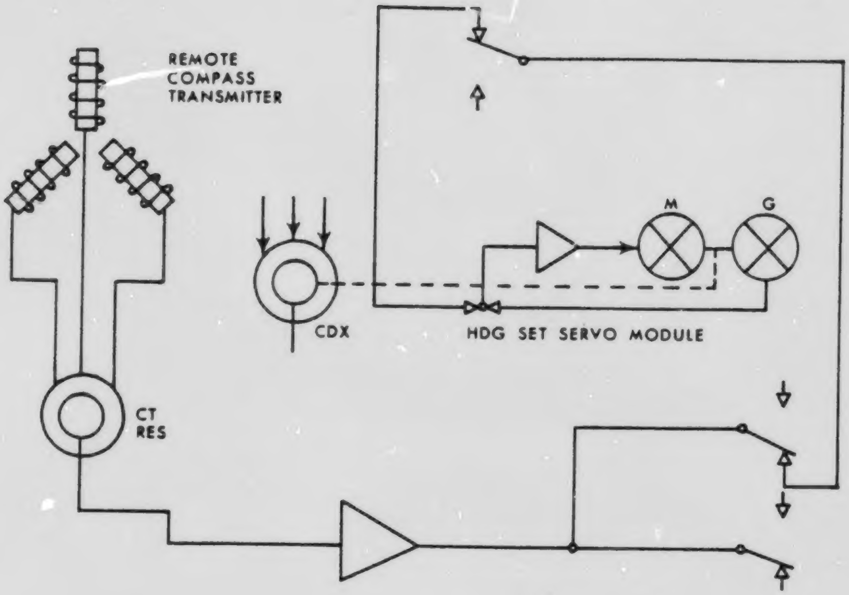
D.

1.

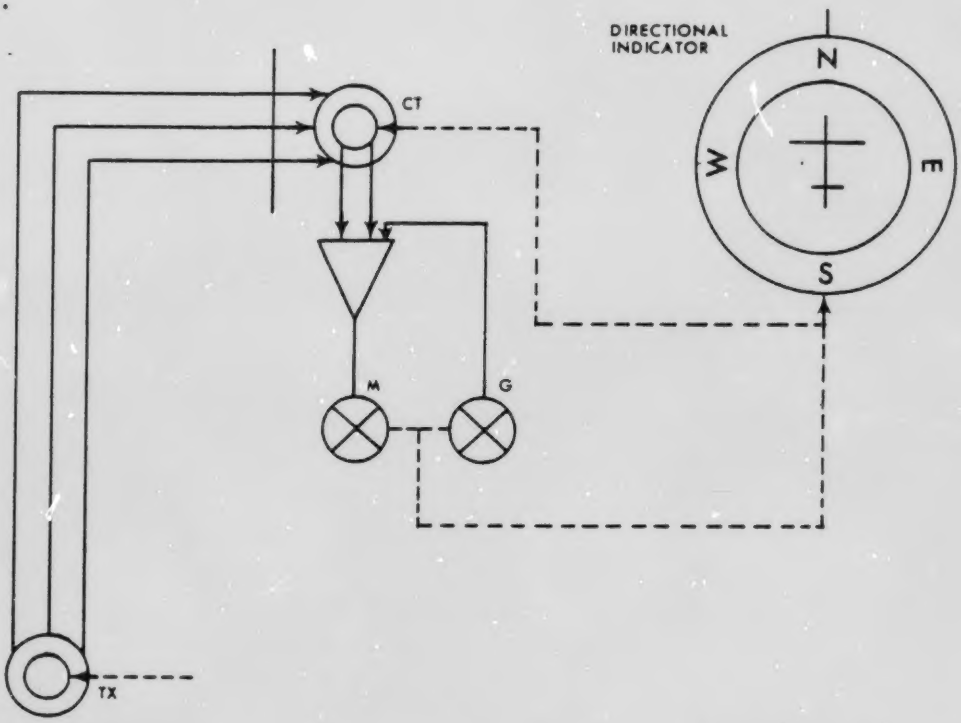

HDG SET RELAY
+
COMP
SLAVE
D G
C Φ
A Φ
+
SLAVE RELAY
+

D.

2.


REMOTE COMPASS TRANSMITTER
CDX
M
G
HDG SET SERVO MODULE
CT RES

3.


DIRECTIONAL INDICATOR
CT
N
W
E
S
M
G
TX

Now ask the instructor for the measurement for section C of this PT.

PART II - Tracing Compass Diagram Circuits

SPECIAL INSTRUCTIONS

This section provides instructions for tracing circuits given in HO-403A-(404). Circuits will be traced, using various colors for circuit distinction. These circuits will then be used in the lab during troubleshooting procedures given in Workbook 3ABR32531-WB-403. Because the compass system is operated in three different modes of operation, some circuits will have more than one color traced on them. Tracing procedures will be outlined by modes of operation, showing the circuits that are used in each mode. Keep in mind that some circuits are used in more than one mode of operation. Now obtain Handout 3ABR32531-HO-403A-(404) from your instructor and follow the instructions given therein.

1. DG Mode

a. Purpose: Used in latitudes above 70 degrees or when the compass transmitter cannot be used.

b. Relays: None energized except when the Heading Set Knob is depressed. Depressing the Heading Set Knob energizes Relay K-1.

c. Circuits used in the DG mode.

(1) Initial Power.

(2) Heading Output from the Displacement Gyro Package (DGP).

(3) Latitude Correction from the Compass System Controller (CSC).

(4) Heading Set from the Compass System Controller (CSC).

d. Initial Power: Trace in RED.

Note: Locate the AC and DC power busses on the left side of the diagram. These provide power to the system.

(1) Gyro spin motor power.

(a) Trace the three phases (A0, B0, and C0) of power into pins 24, 25, and 26 of P1 on the ECA, to the AC and DC junction.

Note: To eliminate the confusion of many wires, this wiring is not drawn through this component.

(b) Continue the gyro spin motor circuitry at pins 80, 81, and 82, at the left of the test board, and trace into the DGP to the DG spin motor.

Note: Gyro power from the AC buss must pass through the contacts of the AFRS relay. This relay is energized when the GYRO-OFF switch (on the ground check panel) is positioned to OFF. This switch is positioned to OFF during maintenance procedures when it is not necessary for the gyro to be in operation.

(c) Trace the 28V DC, from the DC buss, through switch S1 in the Ground Check Panel, to the AFRS power relay (K1). NOTE: Keep in mind that K1 is not energized until the GYRO-OFF switch is positioned to OFF.

(2) Remote Compass Transmitter excitation voltage (23.5V AC). Remote Compass Transmitter Compensator, deviation (NS-EW), adjustment potentiometer reference voltage.

(a) Locate the 23.5V AC, at Pin 20 on P3 of the ECA. Trace this voltage into the Remote Compass Transmitter Compensator. Trace through the power supply to the N-S, E-W adjustment potentiometers. NOTE: Do NOT trace off of the potentiometer Wiper arms. Continue the circuitry out of Pin 5 of P3 (Compensator) and back to ground, at Pin 21 on P3 of the ECA.

(b) Locate the junction between Pins 34 and 304, Pins 35 and 305 on the test board. Trace from these junctions upward to and through the excitation coil of the Remote Compass Transmitter (CX).

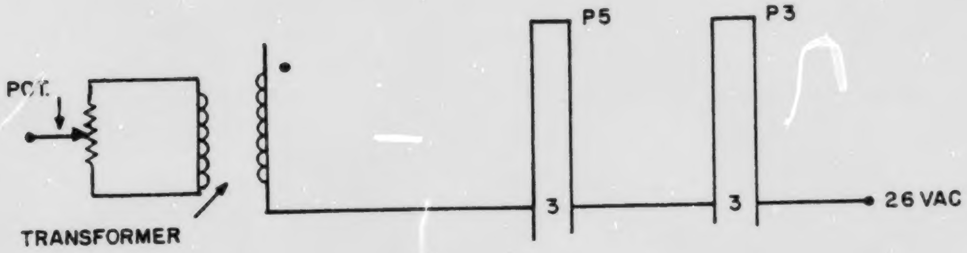
(3) Synchro Rotor Reference Voltage 26V AC.

(a) DGP Heading Synchro: Trace the 26V AC, from the ground, located at the left of Pin 16 on P1 of the ECA, through the rotors of B1-B4 to the 26V AC source, located to the right of synchros B1 and B2.

Note: Synchros B3 and B4 are provided as heading outputs if they are needed. The outputs are not shown because they are not used by the compass system.

(4) 26V AC to the Heading Set Circuitry.

(a) Locate the 26V AC at the right of Pin 3 on P3 of the ECA. Trace this voltage into Pin 3 of P5 and on the Compass System Controller (CSC). Trace in the primary and secondary of the transformer. Also, trace to the potentiometer, but not off of the wiper arm. Refer to the illustration below. The figure below shows only the circuitry to be traced on HO-403A.



Note: The ground for the remainder of this circuit is located at the right of Pin 23 on P3 of the ECA. This is also ground for other circuits.

1759

(5) 27V DC to the Latitude Control Potentiometer.

(a) Locate the 27V DC, at the right of pin 4 on P3 of the ECA. Trace out of Pin 4 to Pin 4 of P5 of the CSC. Continue to and through the Latitude Control Potentiometer. NOTE: Stop immediately after going through the potentiometer. DO NOT trace off of the wiper arm

(6) 28V DC to the relay coils.

Note: These voltage potentials are present at the coils, but the relays are not energized until a ground is provided by the various switches and controls such as the system mode switch and the heading set control knob.

(a) Locate relays K1, K3, K4, K5 and K6 in the ECA. Trace the 28V DC potential, located to the right of each coil, to but not through each coil.

Note: To eliminate the confusion of a lot of wiring through the ECA, the wiring from the DC power source to the relay coils is not shown drawn through the ECA.

(7) Reference Voltage for Synchro B7, in the ECA, when K3 in the ECA is energized.

Note: Whenever K3 is energized (Compass Mode), 26V AC is applied to the stator of synchro B7. This reference voltage enables the synchro to produce signals whenever MG-2 mechanically repositions the rotor of B7.

(a) Locate the 26V AC at the upper right of relay K3 contacts. Trace this voltage to the contacts of relay K3. This potential will be applied to B7 whenever K3 is energized.

e. Heading Signal: Trace in blue.

(1) For a review of the Heading Signal, refer to Frame 3, Section C in PT-403.

(2) Locate the heading synchro (upper left corner) in the DGP. Trace from the stators of the synchro, out of pins 1, 2 and 3 of P1 on the DGP, into Pins 1, 2, and 3 of P2 on the ECA. Continue through the contacts of relay K3 to the stator of B7. From the stator of B7, trace to the stator of synchro B5.

Note: At this point the Heading signal is applied to the Heading Follow-up Module. For a review of the Heading Follow-up Module, refer to Frame 3, Section C (Part I) of this PT.

(3) Trace the resulting output signal from the rotor of B5 into amplifier A3. Trace the mechanical linkage from the motor to the following points.

(a) The generator: Trace its output back to the amplifier.

(b) The rotor of B5: (Note: Repositioning the rotor of B5 nulls out the input signal to the Heading FollowUp module).

(c) The rotor of B6:

1. Repositioning the rotor of B6 nulls the slaving signal from the Remote Compass Transmitter. In the D. G. Mode of operation, the slaving signal is not used. In the D. G. Mode, Latitude Correction voltages compensate for apparent drift.

2. For further explanation, refer to Frames 1 and 2 of Section C in PT-403.

(d) The rotor of B1 through B4: As the motor repositions these rotors, the resulting signals are transmitted to the HSI, BDHI, and the ADI.

(4) Trace the output of B1 into pins R, S, and T of P1 on the Instrument Set Coupler (ISC). Continue the signal through the contacts of K1 to the three junction points. Trace upward through the CDX and out of the ISC to the ADI. Trace the servoloop which controls the sphere in azimuth.

(5) Return to the junction in the ISC and trace downward and out of the ISC through Pins N, P, and Q, continuing to the HSI. Trace the servoloop which controls the HSI azimuth dial.

(6) Return to the ECA and trace the output from the stators of synchro B2 into the BDHI. Trace the servoloop which controls the BDHI azimuth dial.

f. Latitude Correction Circuit: Trace in yellow.

(1) For a review of the Latitude Correction Circuitry refer to Frames 1 and 2 of Section C (Part I) of this PT.

(2) 27V DC has already been applied to the Latitude Correction Potentiometer in the Compass System Controller (CSC). The output taken from the wiper arm is controlled by the Latitude Control Knob which is set to the latitude that the aircraft is in.

(3) Trace the output from the wiper of the latitude control potentiometer out Pin 9 of P5 on the CSC through Pin 9 of P3 on the ECA. Continue through the ECA out Pin 18 of P2. Trace into the DGP to and through the slaving torquer (ST) to ground.

NOTE: The voltages traced from the latitude control potentiometer through the N position of the hemisphere switch is used to control the slave torquer when the aircraft is in the northern hemisphere.

(4) Return to the Latitude Control Potentiometer and trace the signal to the slaving torquer when the hemisphere switch is in the South position.

g. Heading Set Circuitry: Trace in brown.

(1) For a review of the Heading Set operation, refer to frames 4 and 5 in Section C (Part I) of this PT.

(2) Locate the Heading Set Knob in the Compass System Controller and draw the contact to the depressed (down) position. This provides the ground to energize relay K1 in the ECA. Trace the ground, located at the right of Pin 23 on P3 of the ECA, into Pin 23 on P5 of the controller. Continue upward through the Heading Set Knob and out Pin 1 on P5 of the CSC. Trace into the ECA through relay K1 to the DC potential. Draw the contact of K1 to the energized (closed) position.

(3) Return to the Heading Set Potentiometer located below the Heading Set Knob in the CSC. Trace from the wiper arm, out Pin 2 of P5, and into Pin 2 of P3 on the ECA. Continue through the de-energized contacts of relay K4 to amplifier A1. Trace the Heading Set Module circuitry and the mechanical linkage which repositions the rotor of synchro B7.

NOTE: The signal which results when the Heading Set Module repositions the rotor of B7 is the same as the signal which is produced in the DGP when the aircraft turns.

1834

2. Slave Mode of Operation.

a. Purpose: Used between 70 degrees North and 70 degrees South latitudes (where the earth's magnetic field is parallel to the earth).

NOTE: For further explanation refer to Frame 12 of Section B in this PT.

b. Relays:

(1) K4 Slave relay is energized by the Mode Selector Switch, during the Slave Mode of operation.

(2) K1, Heading Set relay, will also be energized when the Heading Set Knob is depressed.

c. Circuits used in the Slave modes.

(1) Initial power.

(2) Heading output from the DGP.

(3) Latitude control from the CSC.

(4) Slaving signal from the Remote Compass Transmitter.

d. Initial Power: Initial power is the same in all modes.

e. Slave Signal: Trace in orange.

(1) For review of the Slave mode and the purpose of the Remote Compass Transmitter output, refer to Frames 7 through 11 of Section C (Part I) of this PT.

(2) Normally, when power is first applied to the system, the mode switch will be in the Slaved position.

NOTE: Relay K4 is energized when the mode switch is positioned to Slave.

(3) Using an orange pencil, draw the CSC mode selector switch to the Slave (S) position.

(4) Trace from the ground, located to the right of Pin 23 on P3 of the ECA, to and through the mode selector switch.

NOTE: This is the same ground which energizes K1 when the Heading Set Knob is depressed.

Continue out of the CSC into Pin 5 of P3 on the ECA. From Pin 5, trace through the contacts of relays K5 and K6 to relay K4. Trace the contacts of relay K4 to the down position.

NOTE: Energizing K4 (Slave) relay provides a complete path for the slaving signal from the remote compass transmitter to be applied to the slave torquer in the DGP.

(5) Locate the Remote Compass Transmitter on the left side of the diagram. Trace the transmitter output, from the CX output leads out of Pins 1, 2, and 3 of P1 on the Remote Compass Transmitter. Continue the signal into the Remote Compass Transmitter Compensator.

NOTE: The purpose of the Remote Compass Transmitter Compensator is to provide a means for correcting the errors.

(6) Trace the correction voltage from the E-W and N-S adjustment potentiometers to the right and apply these to the slaving signal. Continue the slaving signal out Pins 7, 8, and 9 of P3 on the compensator to synchro B6 in the ECA. From the rotor of B6 trace the signal through amplifier A4, the frequency halver, and amplifier A5 to the contacts of relay K4.

(7) Trace through the bottom contacts of K4, through the demodulator and out Pins 17 and 18 of P2 on the ECA. Continue into the DGP, through the slaving torquer to ground.

NOTE: The demodulator changes the AC signal to DC for torquer operation.

(8) Return to the two junction points above the demodulator. Trace the slaving signal to the left, to the two junction points, located to the right of Pins 8 and 9 of P3 on the ECA. Trace the signals up from these junctions and out Pins 6 and 7, continuing into the CSC and apply this signal to the SYNC indicator.

(9) Return to amplifier A5 in the ECA. Trace through the second set of contacts (counting from the bottom) of K4 up to the open contacts of relay K1.

NOTE: If K1 is energized by depressing the Heading Set Knob, the slaving signal will be applied to amplifier A1 which will operate MG-2. Depressing the Heading Set Knob when in the Slave mode causes the system to synchronize.

(10) Trace through the contact of K1 and apply the signal through A1 to MG-2. Trace the mechanical linkage from MG-2 to the rotor of B7.

NOTE: The output of B7 is at this time magnetic heading, which causes the indicators to indicate the direction sensed by the Remote Compass Transmitter (Magnetic Heading of the aircraft).

f. Heading Signal: When the mode selector is in the Slave position and the Heading Set Knob is not depressed, the Heading Signal from the DGP is the same as in the DG mode.

g. Latitude Control: Same as in the DG mode, except that the slave signal is combined with latitude control.

3. Compass Mode of Operation.

a. Purpose: Used when the gyro fails to operate or its output is not accurate.

NOTE: For further explanation refer to Frames 13, 14, and 15 in Section C (Part I) of this PT.

b. Relays:

(1) Relays K1, K3, and K4 are energized in the COMP mode.

(2) Relays K1 and K3 are energized by the mode selector switch during the COMP mode of operation.

(3) Relay K4 is energized by the bottom contacts of relay K3 whenever K3 is energized.

c. Circuits used in the Compass mode.

(1) Initial Power.

(2) Slaving Signal.

(3) Heading output from B7 which is produced by the Slaving signal operating MG-2.

d. Initial Power: Initial power is the same in all modes.

e. Relay Operation: Trace in green.

(1) Using a green pencil, draw the CSC mode selector switch to the COMP (C) position.

(2) Trace from the ground located to the right of Pin 23 on P3 of the ECA to, and through the mode selector switch (now in the COMP position).

NOTE: This is the same ground which energizes K4 in the Slave mode and K1 when the Heading Set Knob is depressed.

(3) Continue out Pin 24, on P5 of the CSC, into Pin 24 on P3 of the ECA, and up to the junction located below relay K1.

(4) Trace through the diode and energize relay K1. Draw the contact of K1 down.

(5) Return to the junction and trace to, and through relay K3 to energize it. Draw its contacts down.

NOTE: When K3 is energized, it provides 26V AC reference voltage to the stator of B7. As this is accomplished, the DGP Heading Signal is eliminated from the ECA circuitry.

(6) Trace the ground located at the right of the bottom contacts of relay K3. Draw the contacts of relay K4 to the energized (down) position.

f. Circuitry:

(1) Due to the fact that the Remote Compass Transmitter output is used in both the Slave and Comp modes, the signal need not be retraced.

(2) Visually trace the transmitter output (orange) to the ECA. Follow the circuitry through B6, A4, Frequency Halver, and A5.

(3) Follow the signal through the middle contacts of relay K4 and continue through the contact of relay K1. Trace through amplifier A1 to MG-2.

(4) MG-2 mechanically repositions the rotor of B7 which has 26V AC applied to its stator, thereby producing a heading output.

(5) The output of B7 follows the same path to the indicators as the heading output does in the DG or Slave modes.

NOTE: In the Compass mode, the indicators indicate the magnetic heading sensed by the Remote Compass Transmitter.

If you understand the system operation and have colored in all the system circuitry, you are ready to start troubleshooting on the trainer.

PREPARE THE MAN

HANDOUT 3ABR32531-HO-403
3ABR32632B-HO-502

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionics Systems Specialist

Attitude Heading Reference and Gyro Stabilized Magnetic Compass Systems

25 October 1974

AIR TRAINING COMMAND

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR32531-HO-303, 6 November 1972.
OPR: TAS
DISTRIBUTION: X
TAS - 900; TTOC - 3

Designed For ATC Course Use

DO NOT USE ON THE JOB

1768

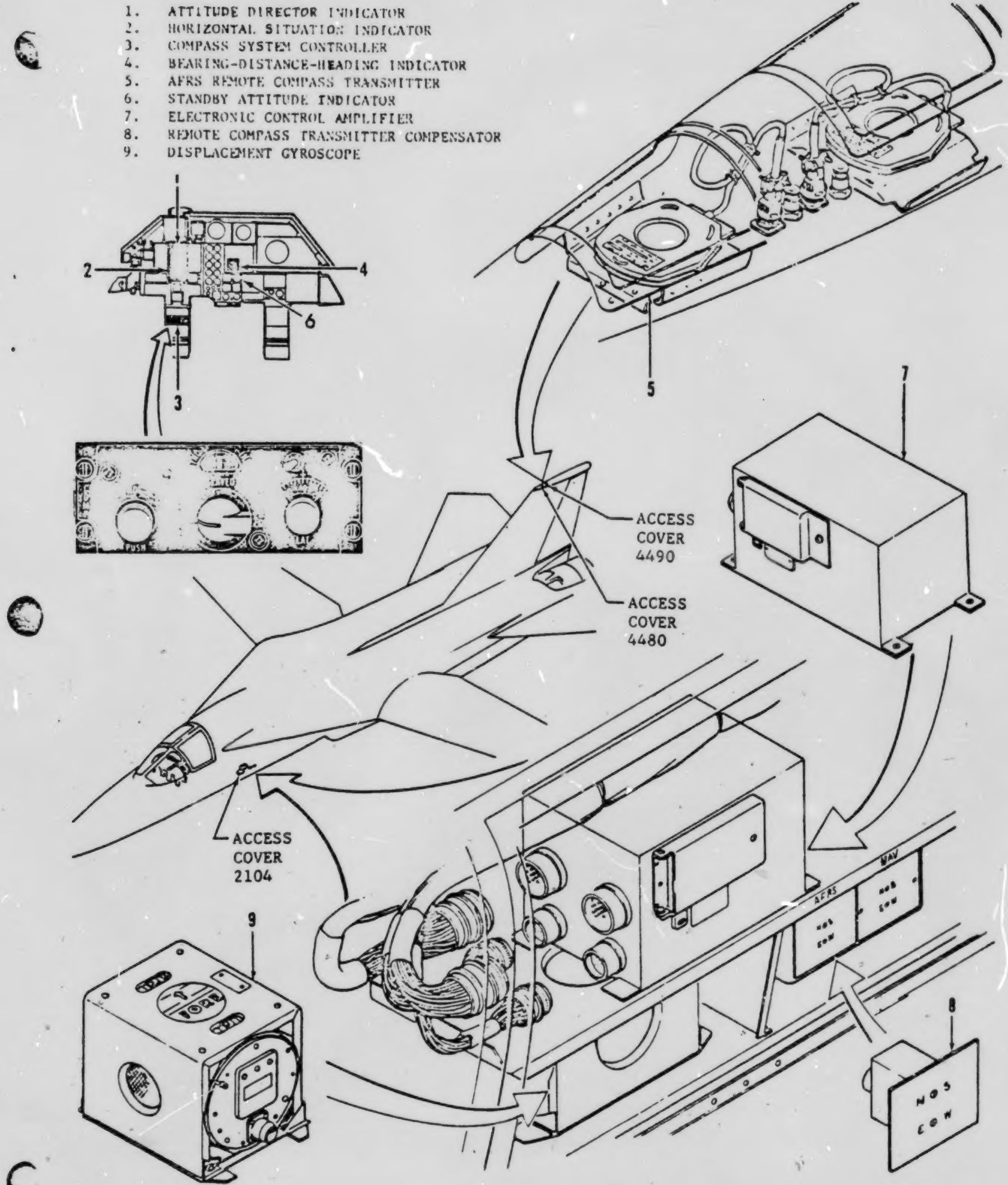
Instrument/Flight Control Branch
Chanute AFB, Illinois

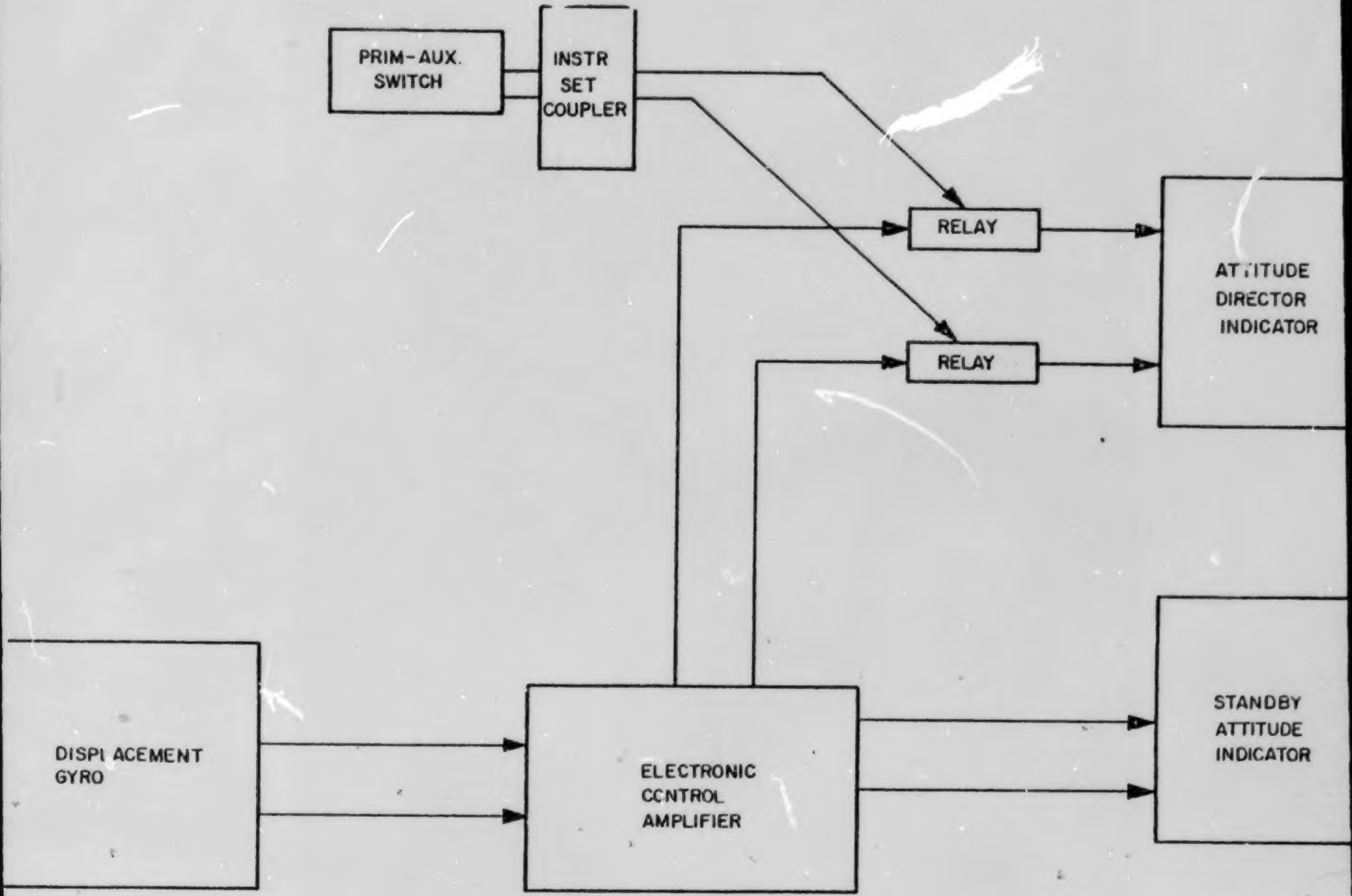
3ABR32531-HO-403
3ABR32632B-HO-502

This handout contains drawings and block diagrams of the Auxiliary Flight Reference System. Pages 1 through 8 will be used with section A of 3ABR32531-PT-403 and 3ABR32632B-PT-502B; pages 9 and 10 with section B; and pages 11 through 18 with section C.

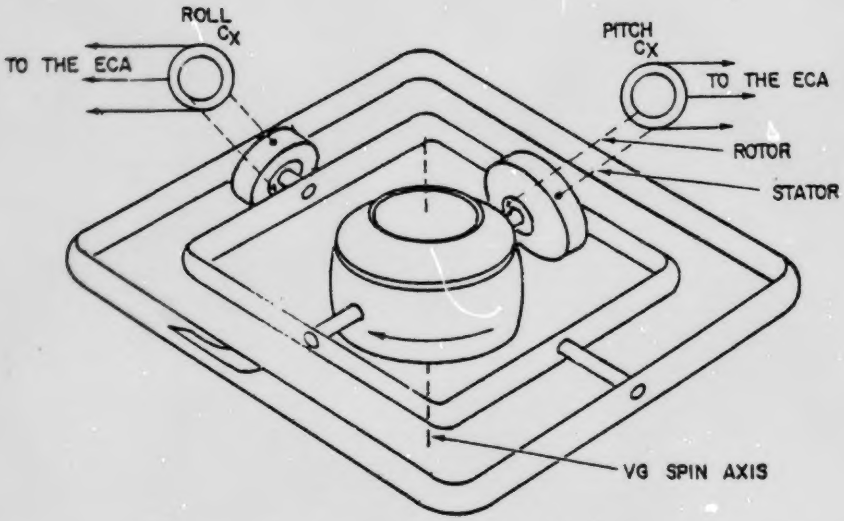
1841

1. ATTITUDE DIRECTOR INDICATOR
2. HORIZONTAL SITUATION INDICATOR
3. COMPASS SYSTEM CONTROLLER
4. BEARING-DISTANCE-HEADING INDICATOR
5. AFRS REMOTE COMPASS TRANSMITTER
6. STANDBY ATTITUDE INDICATOR
7. ELECTRONIC CONTROL AMPLIFIER
8. REMOTE COMPASS TRANSMITTER COMPENSATOR
9. DISPLACEMENT GYROSCOPE


1
2
4
6
3
PUSH
5
7
ACCESS COVER 4490
ACCESS COVER 4480
ACCESS COVER 2104
9
AFRS
NAV
8

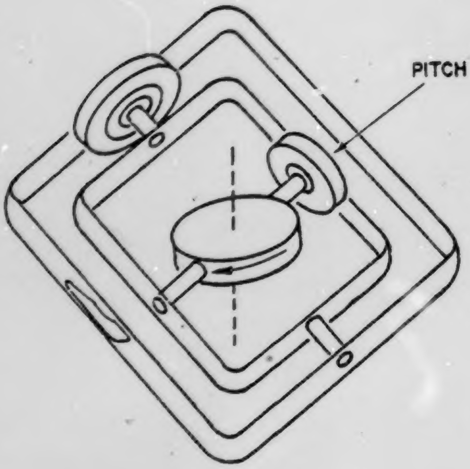

PRIM-AUX. SWITCH
INSTR SET COUPLER
RELAY
RELAY
ATTITUDE DIRECTOR INDICATOR
DISPLACEMENT GYRO
ELECTRONIC CONTROL AMPLIFIER
STANDBY ATTITUDE INDICATOR

1843

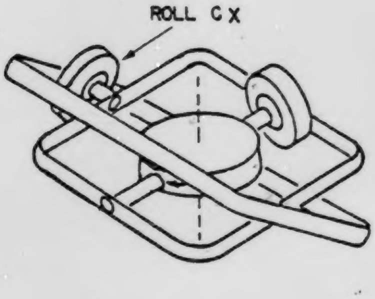

ROLL CX
TO THE ECA
PITCH CX
TO THE ECA
ROTOR
STATOR
VG SPIN AXIS

AIRCRAFT IN LEVEL FLIGHT

FIGURE A



AIRCRAFT NOSE UP
FIGURE B



AIRCRAFT ROLL RIGHT
FIGURE C

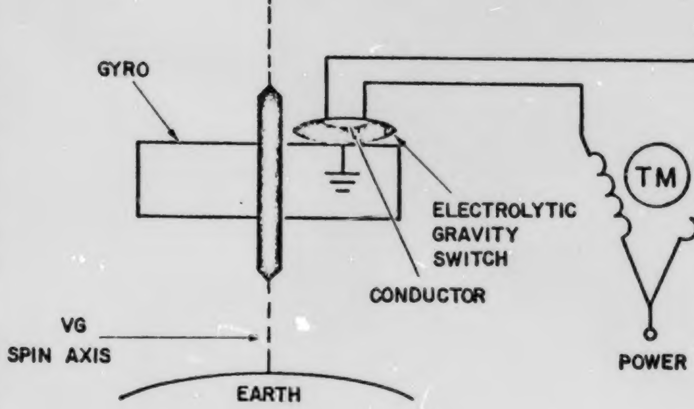

GYRO
ELECTROLYTIC
GRAVITY
SWITCH
CONDUCTOR
TM
VG
SPIN AXIS
EARTH
POWER

FIGURE A

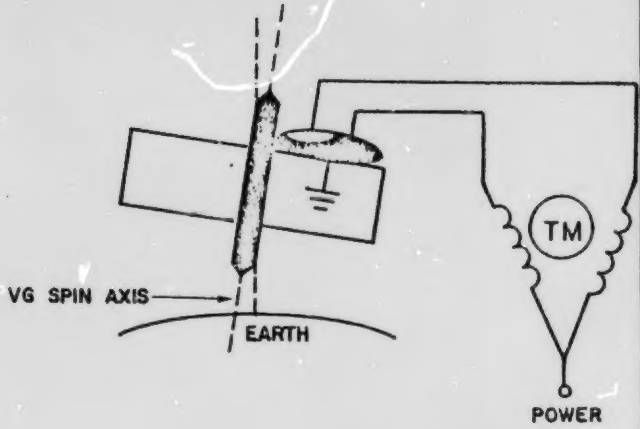

TM
VG SPIN AXIS
EARTH
POWER

FIGURE B

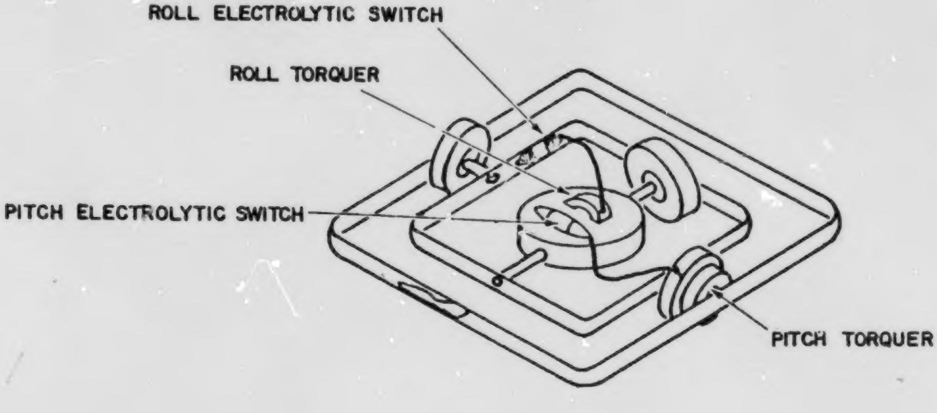
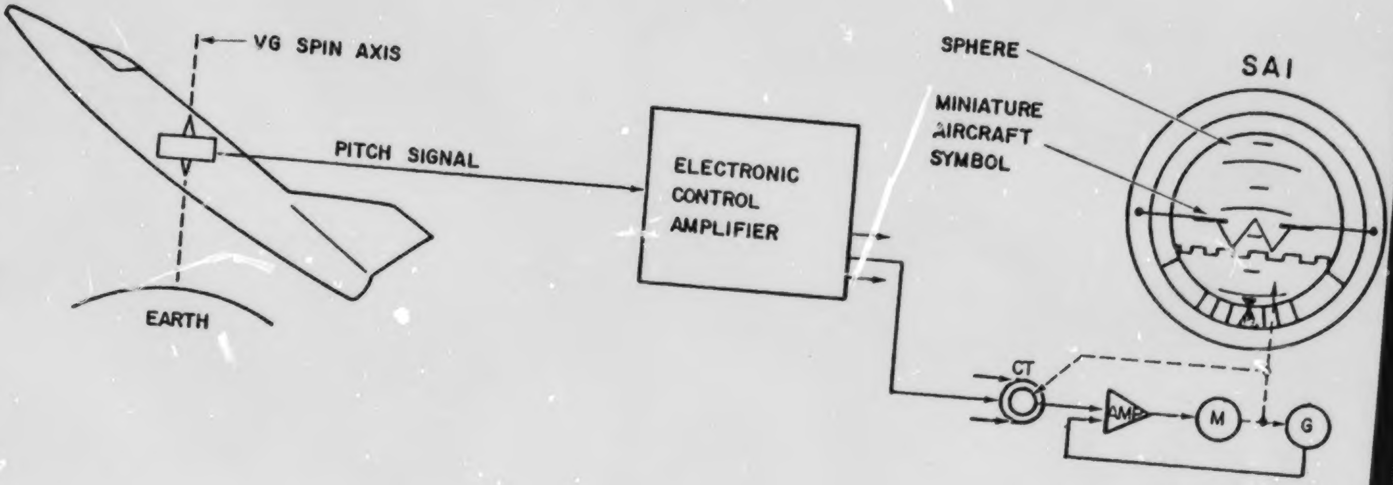
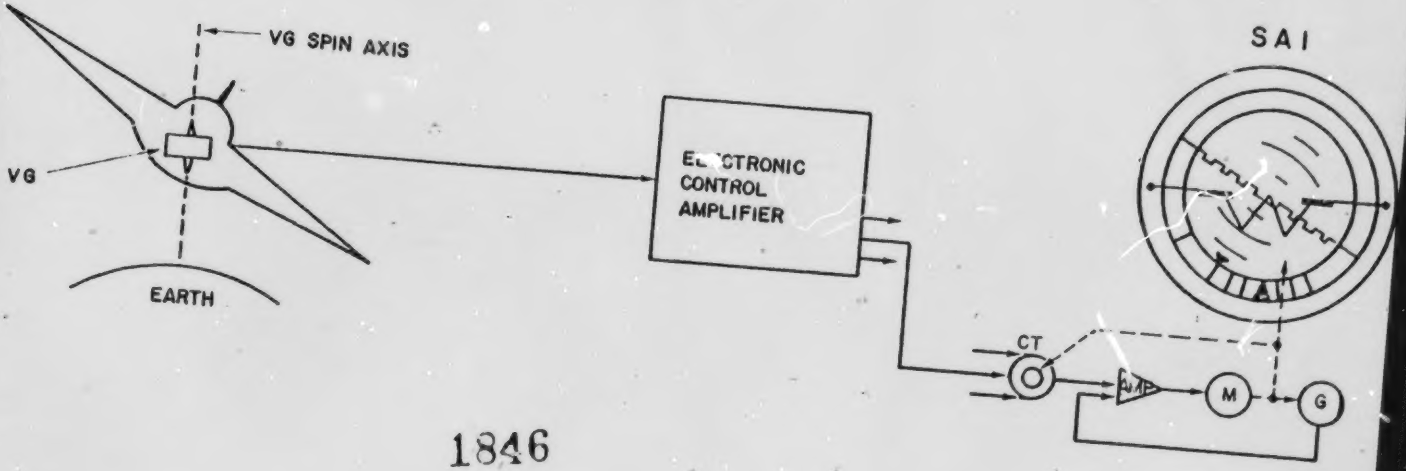

ROLL ELECTROLYTIC SWITCH
ROLL TORQUER
PITCH ELECTROLYTIC SWITCH
PITCH TORQUER

FIGURE C


VG SPIN AXIS
PITCH SIGNAL
EARTH
ELECTRONIC CONTROL AMPLIFIER
SPHERE
MINIATURE AIRCRAFT SYMBOL
SAI
CT
AMP
M
G


VG SPIN AXIS
VG
EARTH
ELECTRONIC CONTROL AMPLIFIER
SAI
CT
AMP
M
G

1846

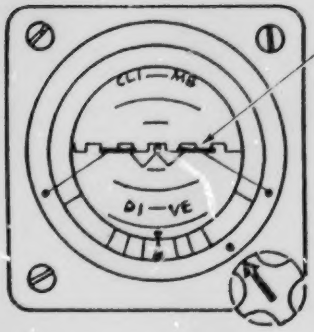


FIGURE A

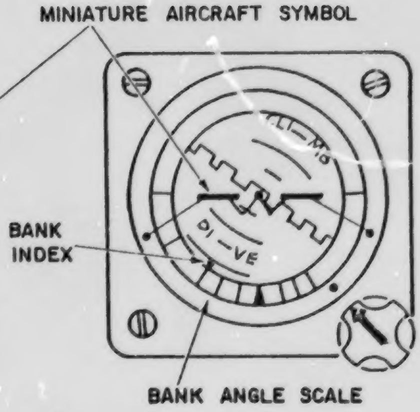

MINIATURE AIRCRAFT SYMBOL
CLI—MB
DI—VE
BANK INDEX
BANK ANGLE SCALE

FIGURE B

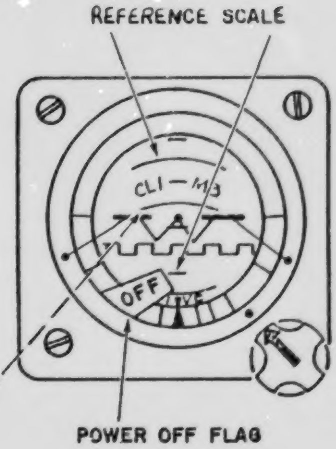

REFERENCE SCALE
CLI—MB
OFF
POWER OFF FLAG

FIGURE C

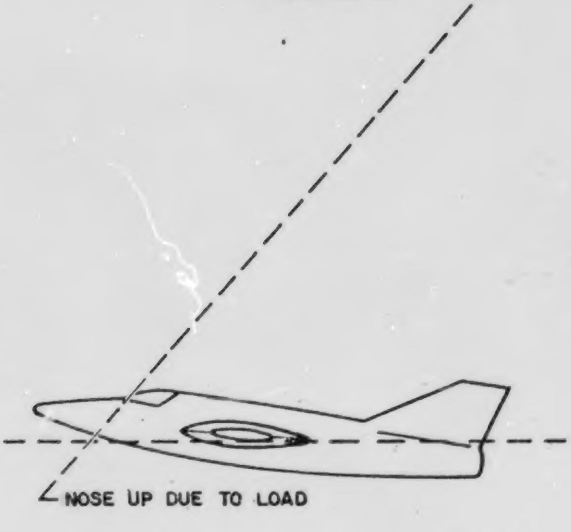

NOSE UP DUE TO LOAD

FIGURE D

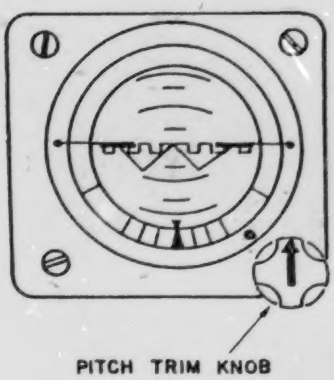
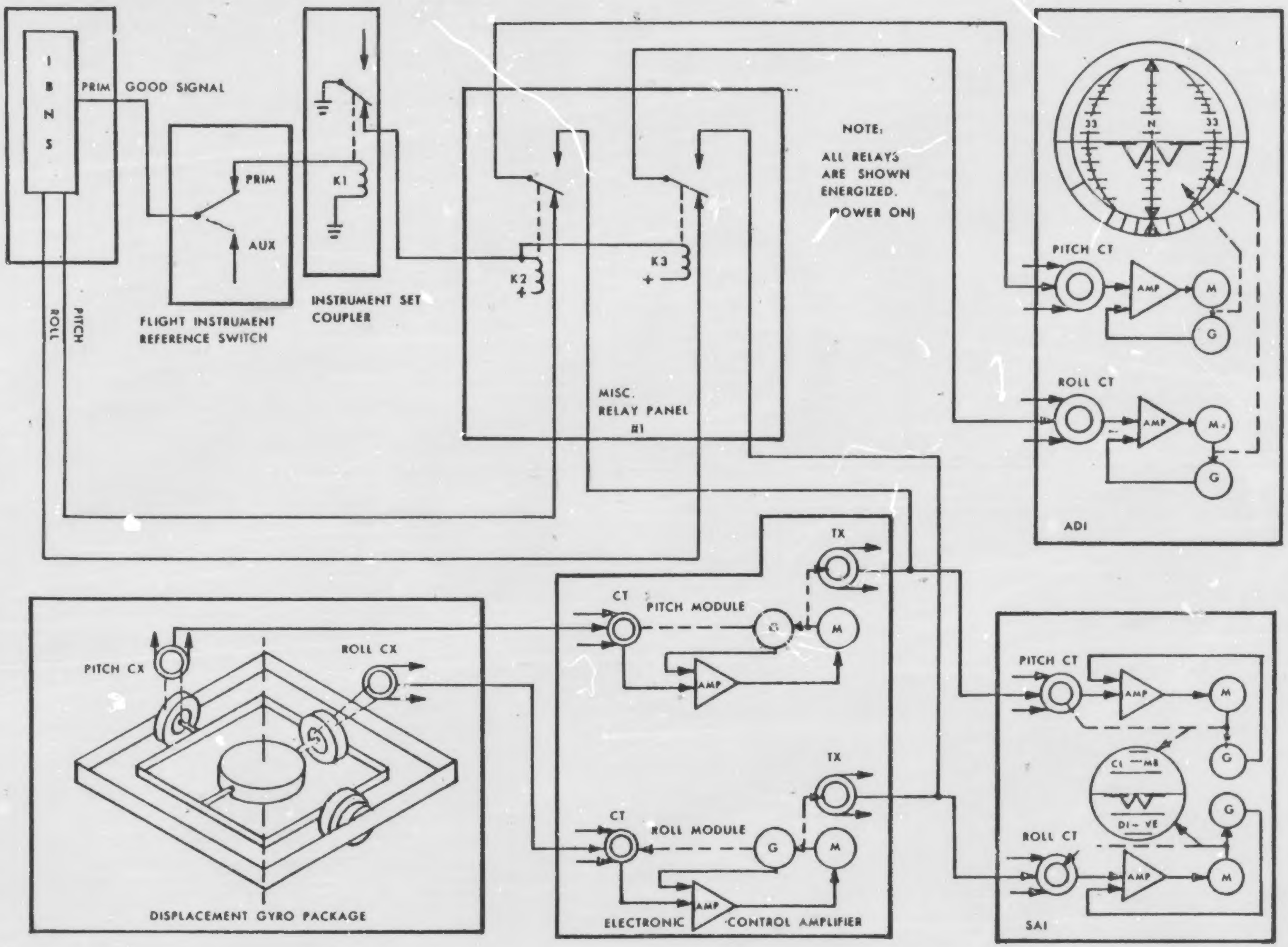

PITCH TRIM KNOB

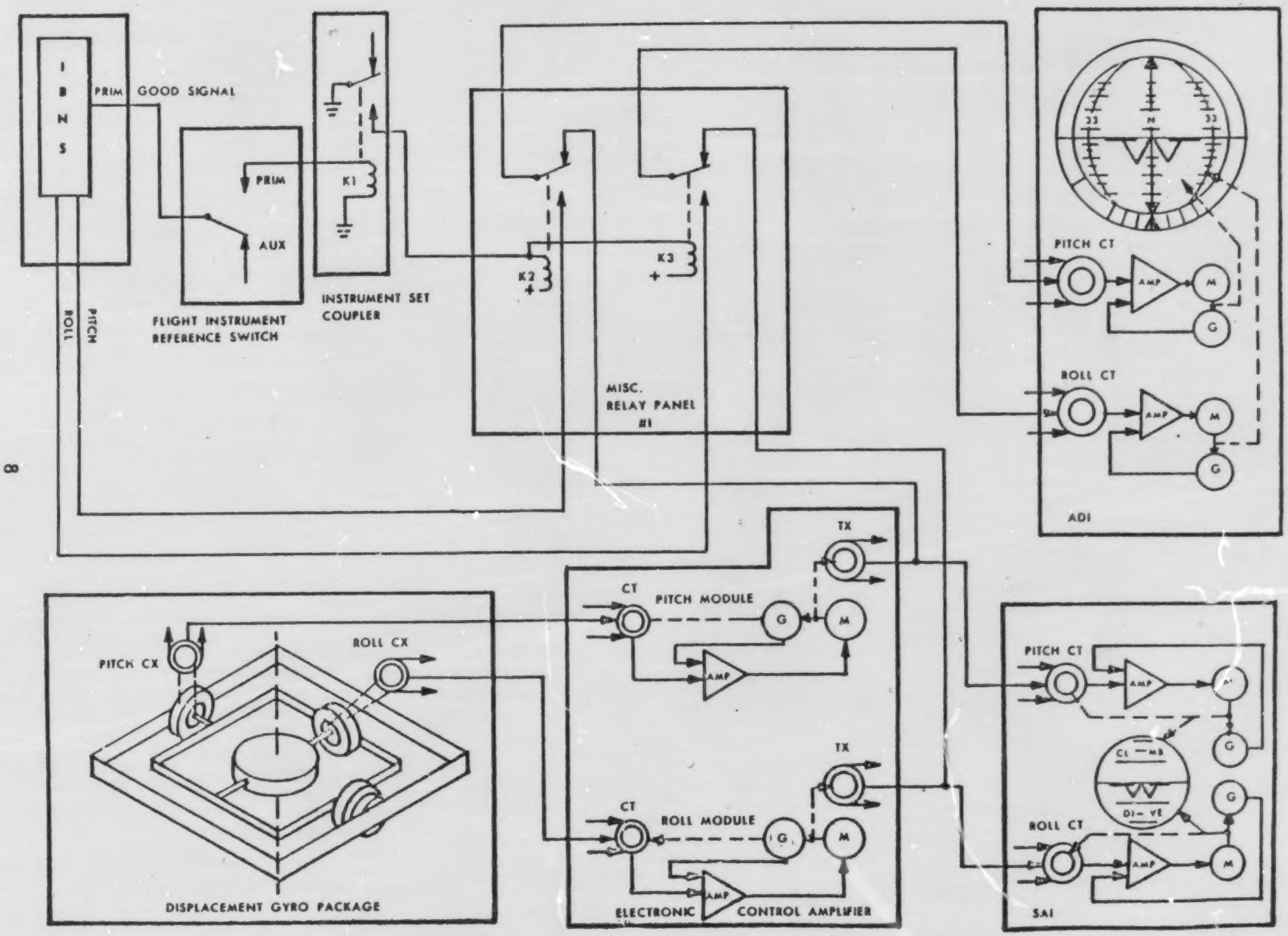
FIGURE E


IBNS
PRIM
GOOD SIGNAL
ROLL
PITCH
PRIM
AUX
FLIGHT INSTRUMENT REFERENCE SWITCH
K1
INSTRUMENT SET COUPLER
K2
K3
MISC. RELAY PANEL #1
NOTE:
ALL RELAYS ARE SHOWN ENERGIZED. (POWER ON)
33
N
33
PITCH CT
AMP
M
G
ROLL CT
AMP
M
G
ADI
PITCH CX
ROLL CX
DISPLACEMENT GYRO PACKAGE
TX
CT
PITCH MODULE
G
M
AMP
TX
CT
ROLL MODULE
G
M
AMP
ELECTRONIC CONTROL AMPLIFIER
PITCH CT
AMP
M
G
CL
MB
DI
VE
G
ROLL CT
AMP
M
SAI

1848

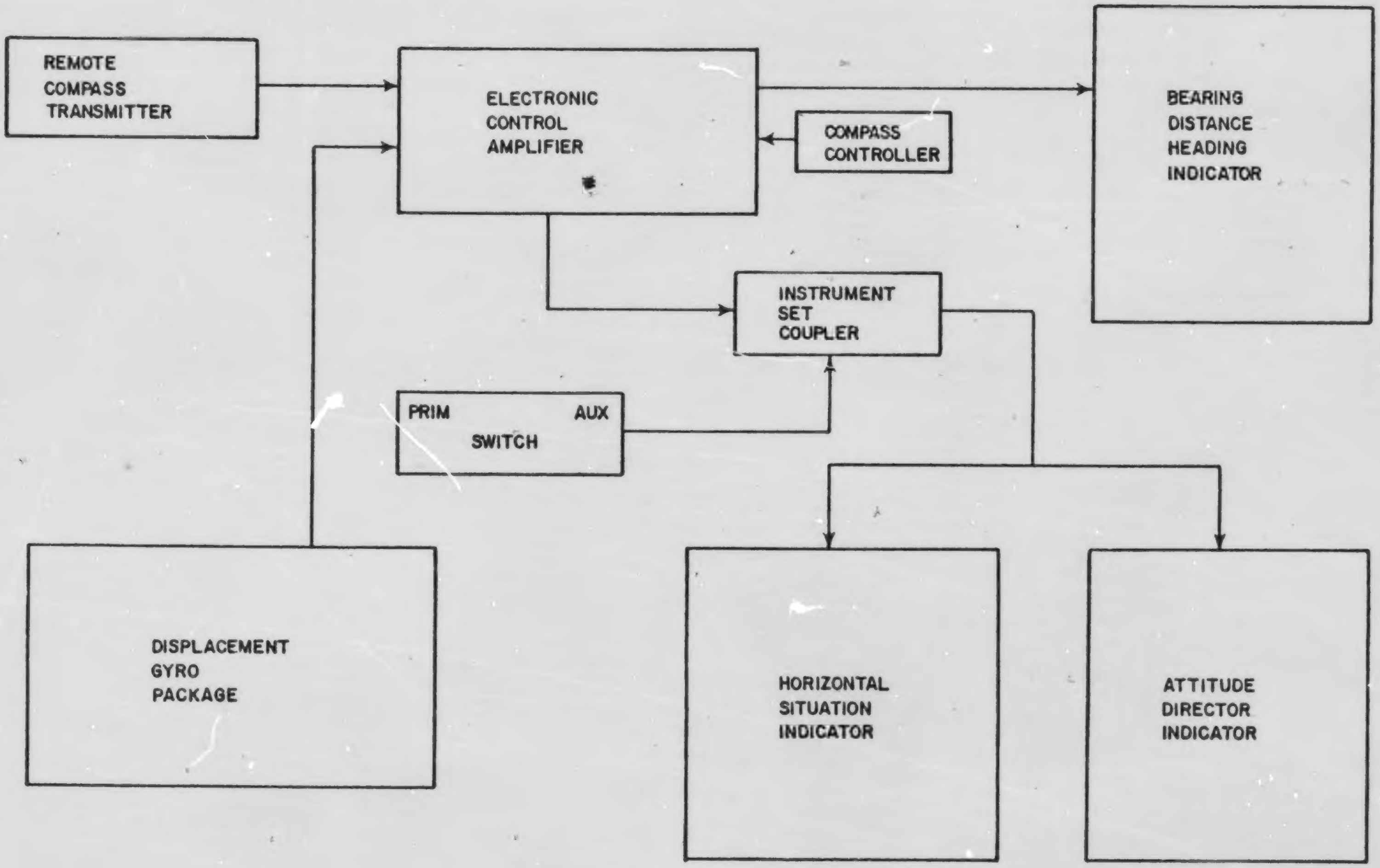
1849

1776


I
B
N
S
PRIM
GOOD SIGNAL
PRIM
AUX
FLIGHT INSTRUMENT REFERENCE SWITCH
K1
INSTRUMENT SET COUPLER
K2
+
K3
+
MISC. RELAY PANEL #1
ROLL
PITCH
33
N
33
PITCH CT
AMP
M
G
ROLL CT
AMP
M
G
ADI
PITCH CX
ROLL CX
DISPLACEMENT GYRO PACKAGE
CT
PITCH MODULE
G
M
TX
AMP
CT
ROLL MODULE
G
M
TX
AMP
ELECTRONIC CONTROL AMPLIFIER
PITCH CT
AMP
M
G
CL — MB
DI — VE
G
ROLL CT
AMP
M
SAI

1850

1851


REMOTE COMPASS TRANSMITTER
ELECTRONIC CONTROL AMPLIFIER
COMPASS CONTROLLER
BEARING DISTANCE HEADING INDICATOR
INSTRUMENT SET COUPLER
PRIM
AUX
SWITCH
DISPLACEMENT GYRO PACKAGE
HORIZONTAL SITUATION INDICATOR
ATTITUDE DIRECTOR INDICATOR

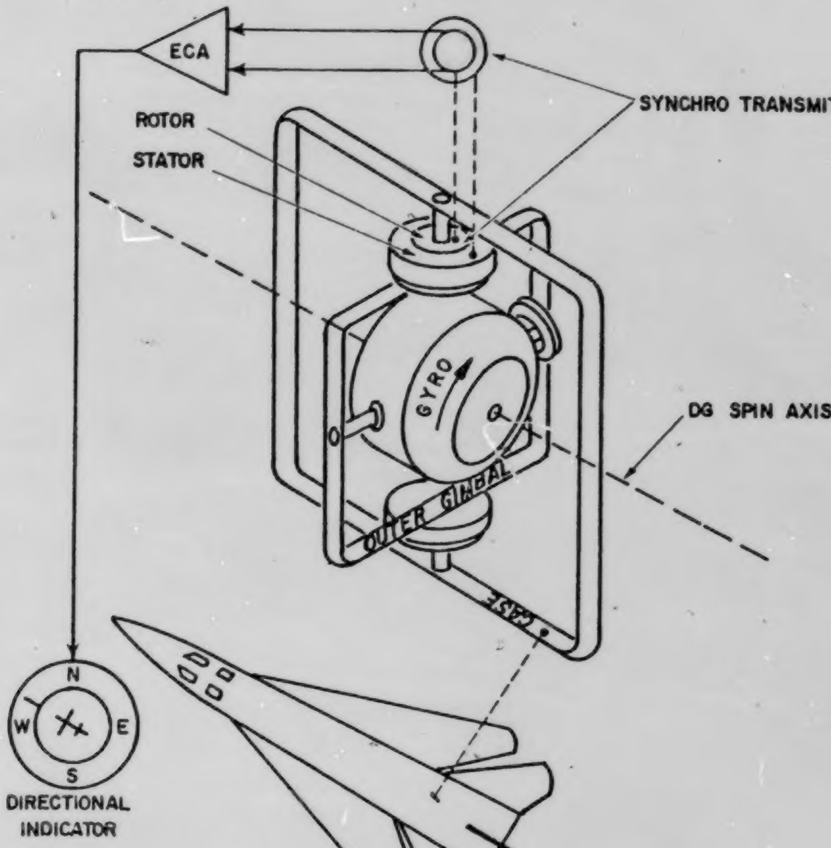

ECA
ROTOR
STATOR
SYNCHRO TRANSMITTER
GYRO
OUTER GIMBAL
CASE
DG SPIN AXIS
N
W
E
S
DIRECTIONAL INDICATOR

FIG. A

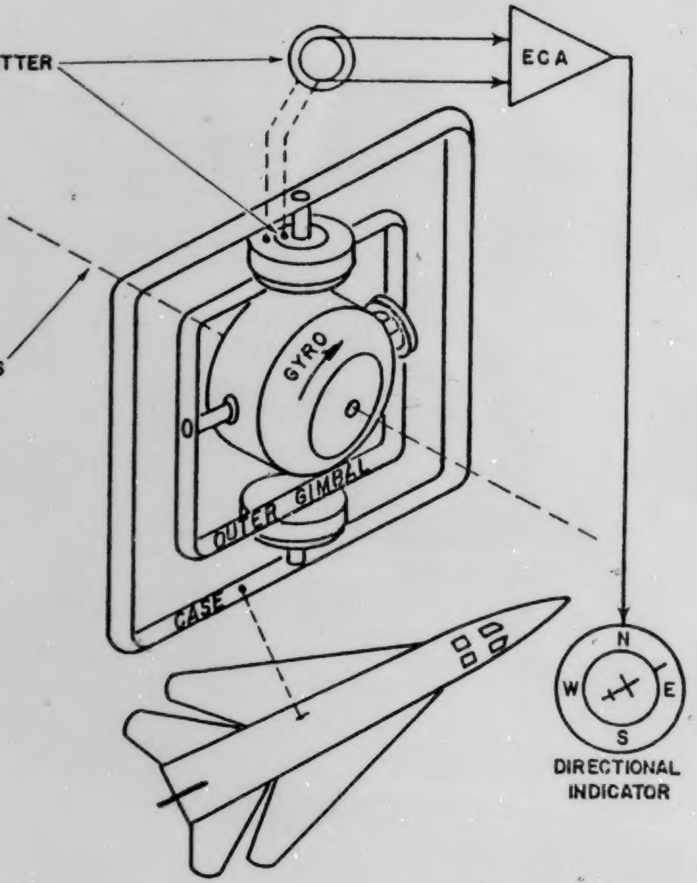
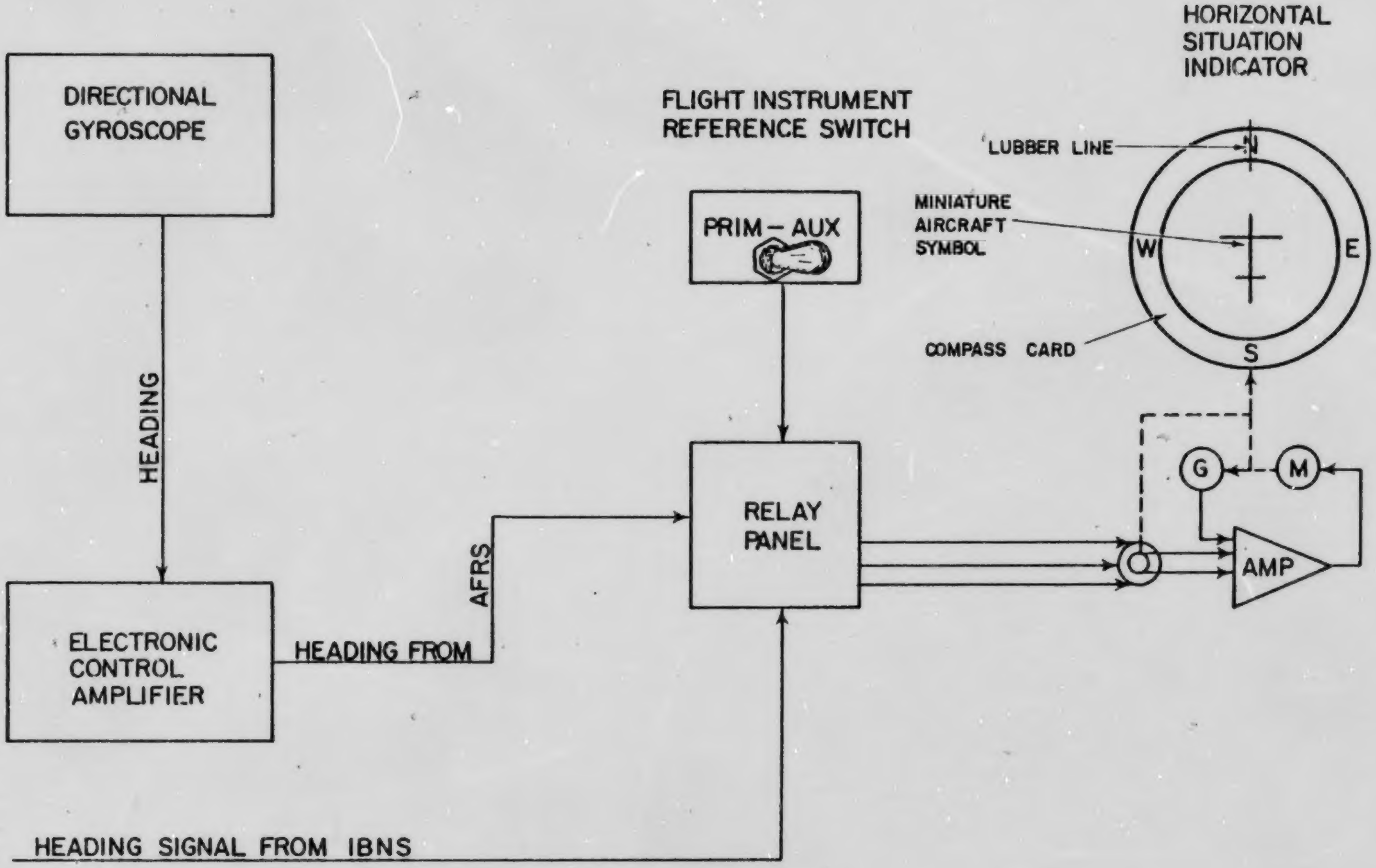

ECA
GYRO
OUTER GIMBAL
CASE
N
W
E
S
DIRECTIONAL INDICATOR

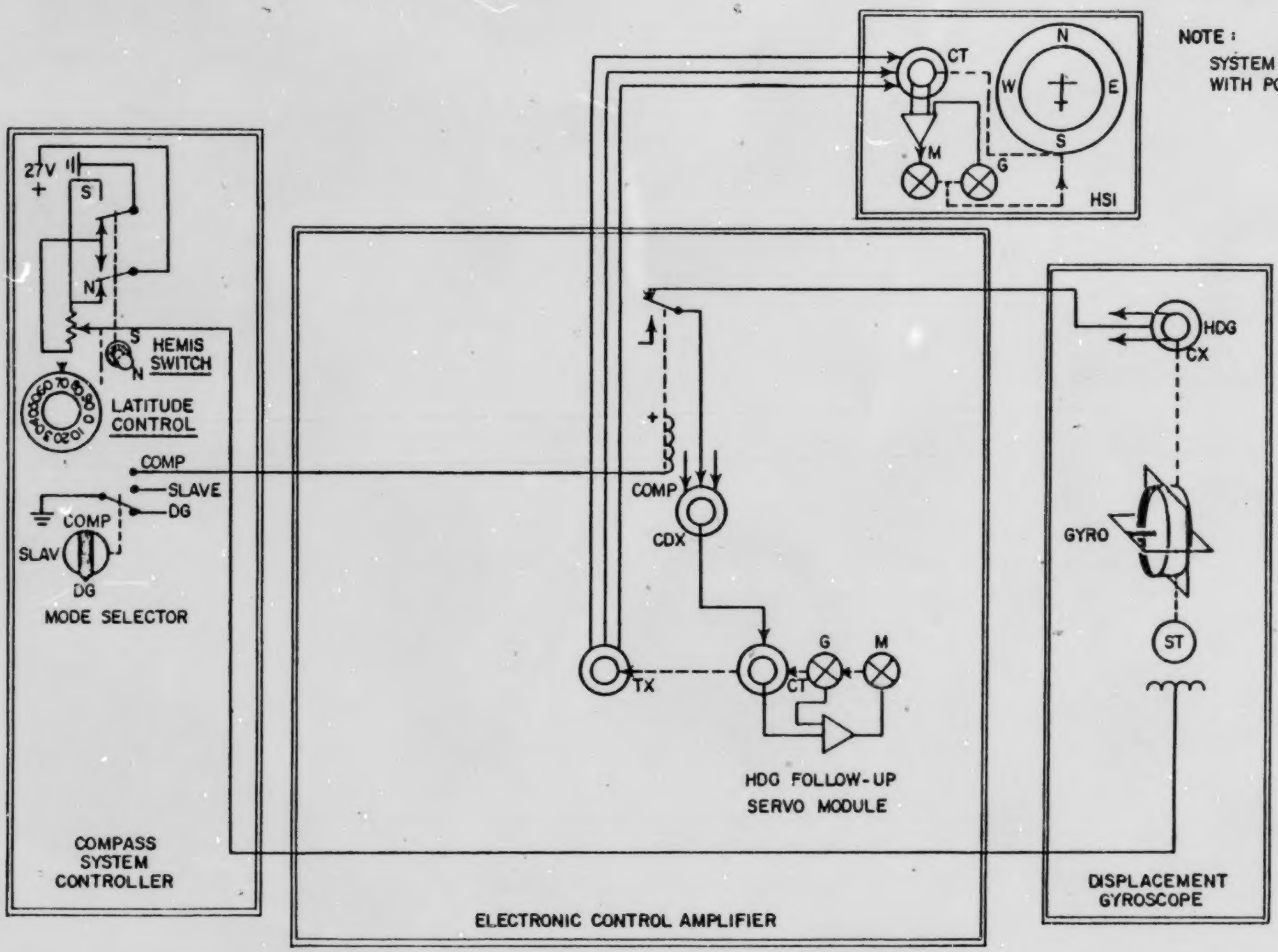
FIG. B

1854

1855


HORIZONTAL SITUATION INDICATOR
DIRECTIONAL GYROSCOPE
FLIGHT INSTRUMENT REFERENCE SWITCH
LUBBER LINE
N
PRIM – AUX
MINIATURE AIRCRAFT SYMBOL
W
E
COMPASS CARD
S
HEADING
G
M
RELAY PANEL
AFRS
AMP
ELECTRONIC CONTROL AMPLIFIER
HEADING FROM
HEADING SIGNAL FROM IBNS

1779


27V
+
S
N
S
HEMIS SWITCH
N
70
60
50
40
30
20
10
0
LATITUDE CONTROL
COMP
SLAVE
DG
COMP
SLAV
DG
MODE SELECTOR
COMPASS SYSTEM CONTROLLER
CT
N
W
E
S
M
G
HSI
+
COMP
CDX
TX
CT
G
M
HDG FOLLOW-UP SERVO MODULE
ELECTRONIC CONTROL AMPLIFIER
HDG
CX
GYRO
ST
DISPLACEMENT GYROSCOPE

NOTE:
SYSTEM IS SHOWN
WITH POWER ON.

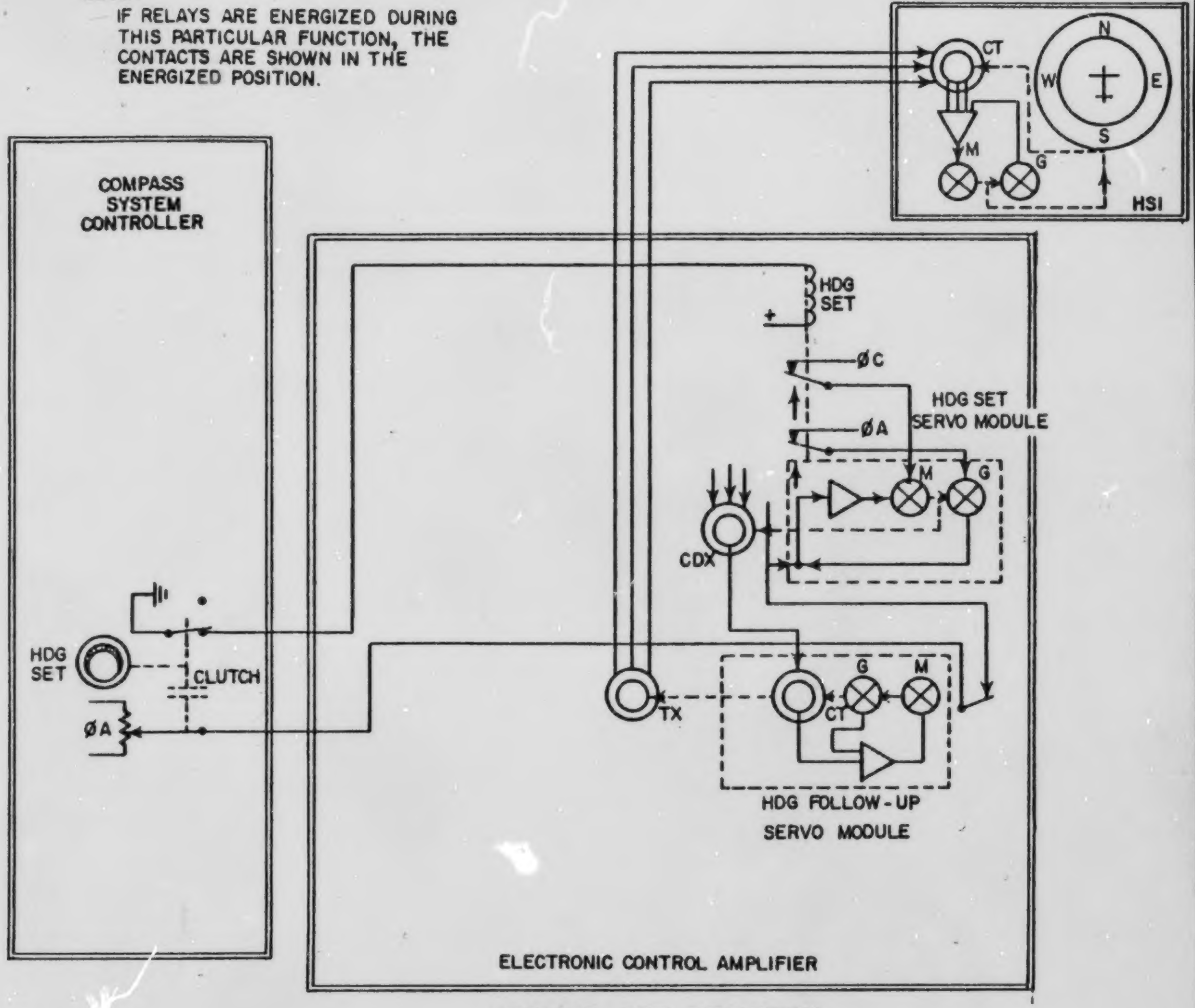
1858

1859

D.G. MODE WITH LATITUDE CORRECTION

NOTE:

IF RELAYS ARE ENERGIZED DURING THIS PARTICULAR FUNCTION, THE CONTACTS ARE SHOWN IN THE ENERGIZED POSITION.

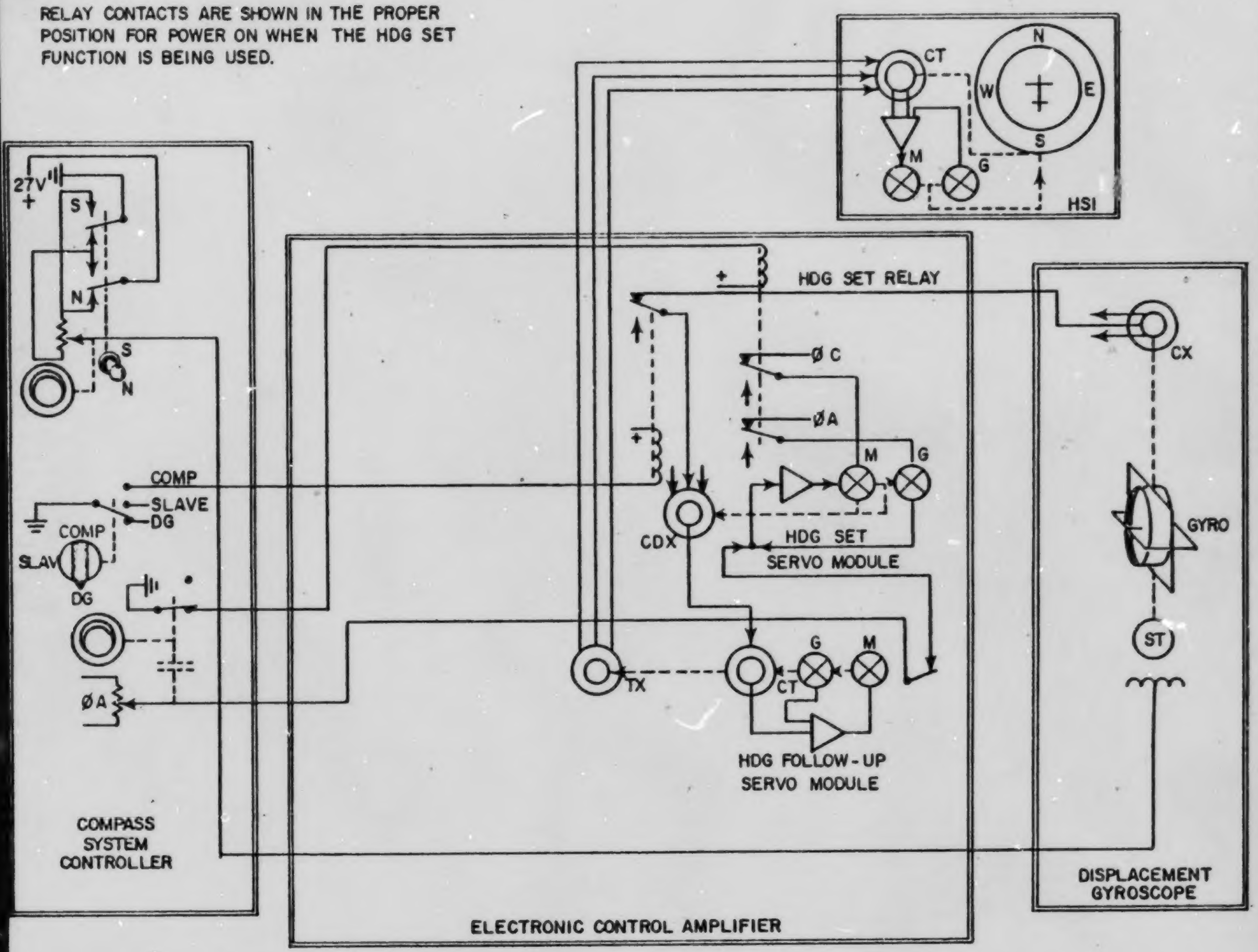


CT
N
W
E
S
M
G
HSI
COMPASS SYSTEM CONTROLLER
HDG SET
+
ØC
ØA
HDG SET SERVO MODULE
M
G
CDX
HDG SET
CLUTCH
ØA
G
M
TX
CT
HDG FOLLOW-UP SERVO MODULE
ELECTRONIC CONTROL AMPLIFIER

HEADING SET CIRCUITRY

NOTE:

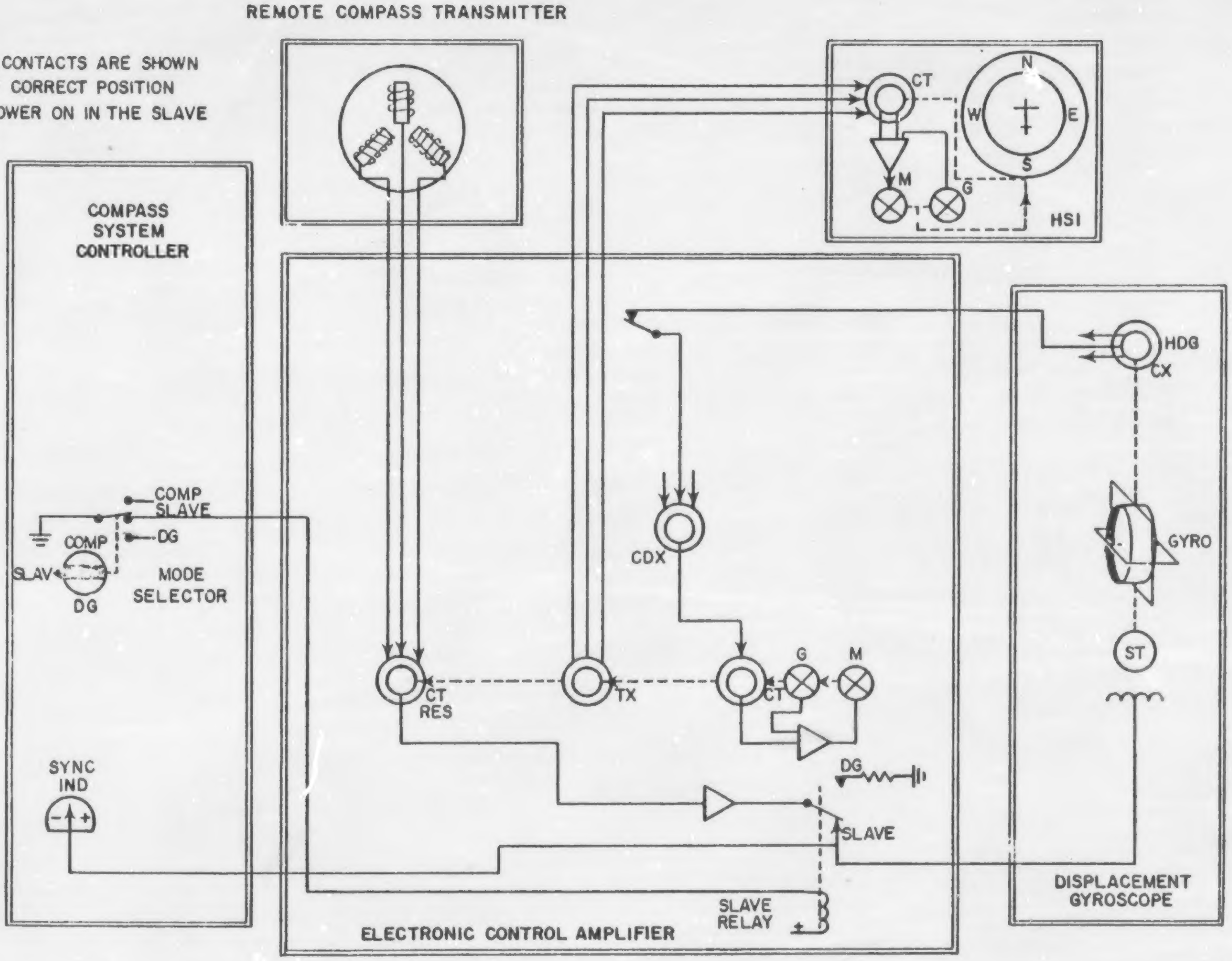
RELAY CONTACTS ARE SHOWN IN THE PROPER POSITION FOR POWER ON WHEN THE HDG SET FUNCTION IS BEING USED.


CT
N
W
E
S
M
G
HSI
27V
+
S
N
S
N
HDG SET RELAY
+
ØC
ØA
M
G
CX
COMP
SLAVE
DG
COMP
SLAV
DG
CDX
HDG SET
SERVO MODULE
GYRO
ST
G
M
TX
CT
ØA
HDG FOLLOW-UP
SERVO MODULE
COMPASS
SYSTEM
CONTROLLER
DISPLACEMENT
GYROSCOPE
ELECTRONIC CONTROL AMPLIFIER

D.G. MODE WITH LATITUDE CONTROL AND HEADING SET

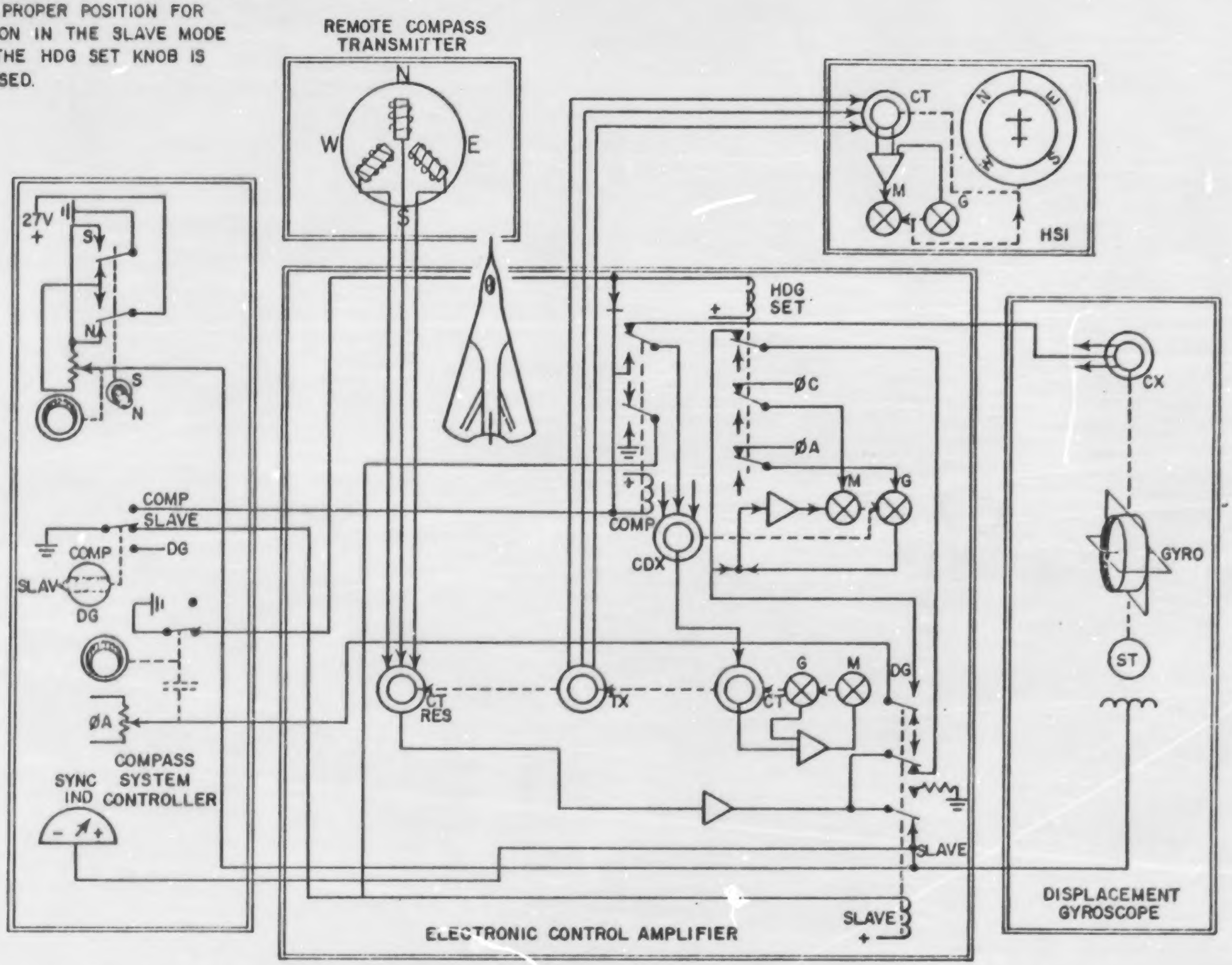
1861

NOTE:
RELAY CONTACTS ARE SHOWN IN THE CORRECT POSITION FOR POWER ON IN THE SLAVE MODE.


REMOTE COMPASS TRANSMITTER
CT
N
W
E
S
M
G
HSI
COMPASS SYSTEM CONTROLLER
COMP
SLAVE
DG
COMP
SLAV
DG
MODE SELECTOR
SYNC IND
HDG
CX
GYRO
ST
CDX
G
M
CT RES
TX
CT
DG
SLAVE
SLAVE RELAY
ELECTRONIC CONTROL AMPLIFIER
DISPLACEMENT GYROSCOPE

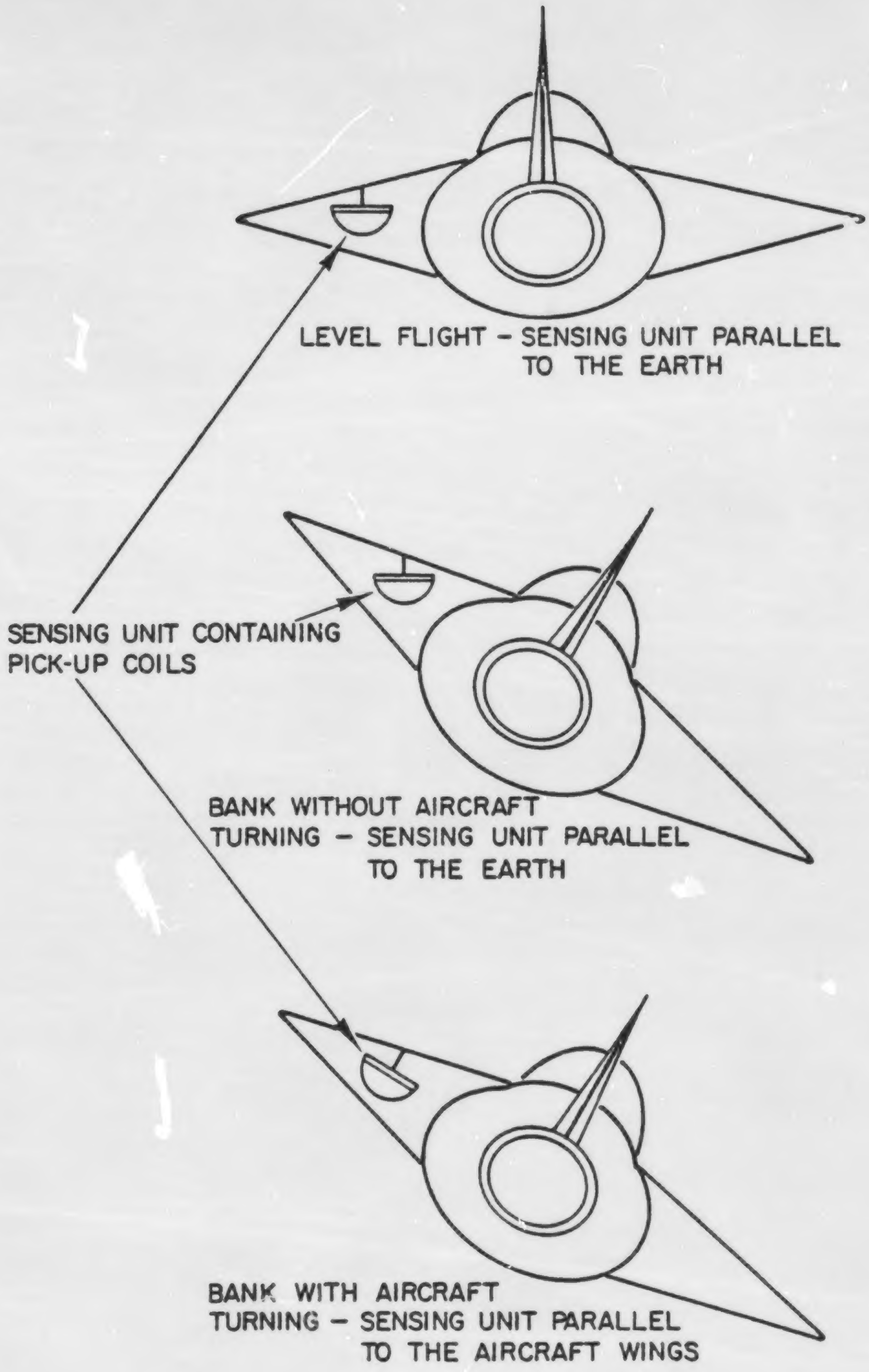
1784

NOTE:
ALL RELAY CONTACTS ARE SHOWN IN THE PROPER POSITION FOR POWER ON IN THE SLAVE MODE WHEN THE HDG SET KNOB IS DEPRESSED.


REMOTE COMPASS TRANSMITTER
N
W
E
S
CT
N
E
S
W
M
G
HSI
27V
+
S
N
S
N
HDG SET
+
ØC
ØA
M
G
COMP
CDX
CX
GYRO
ST
COMP
SLAVE
DG
COMP
SLAV
DG
ØA
CT RES
TX
G
M
CT
DG
SLAVE
COMPASS SYSTEM CONTROLLER
SYNC IND
- +
SLAVE
+
ELECTRONIC CONTROL AMPLIFIER
DISPLACEMENT GYROSCOPE

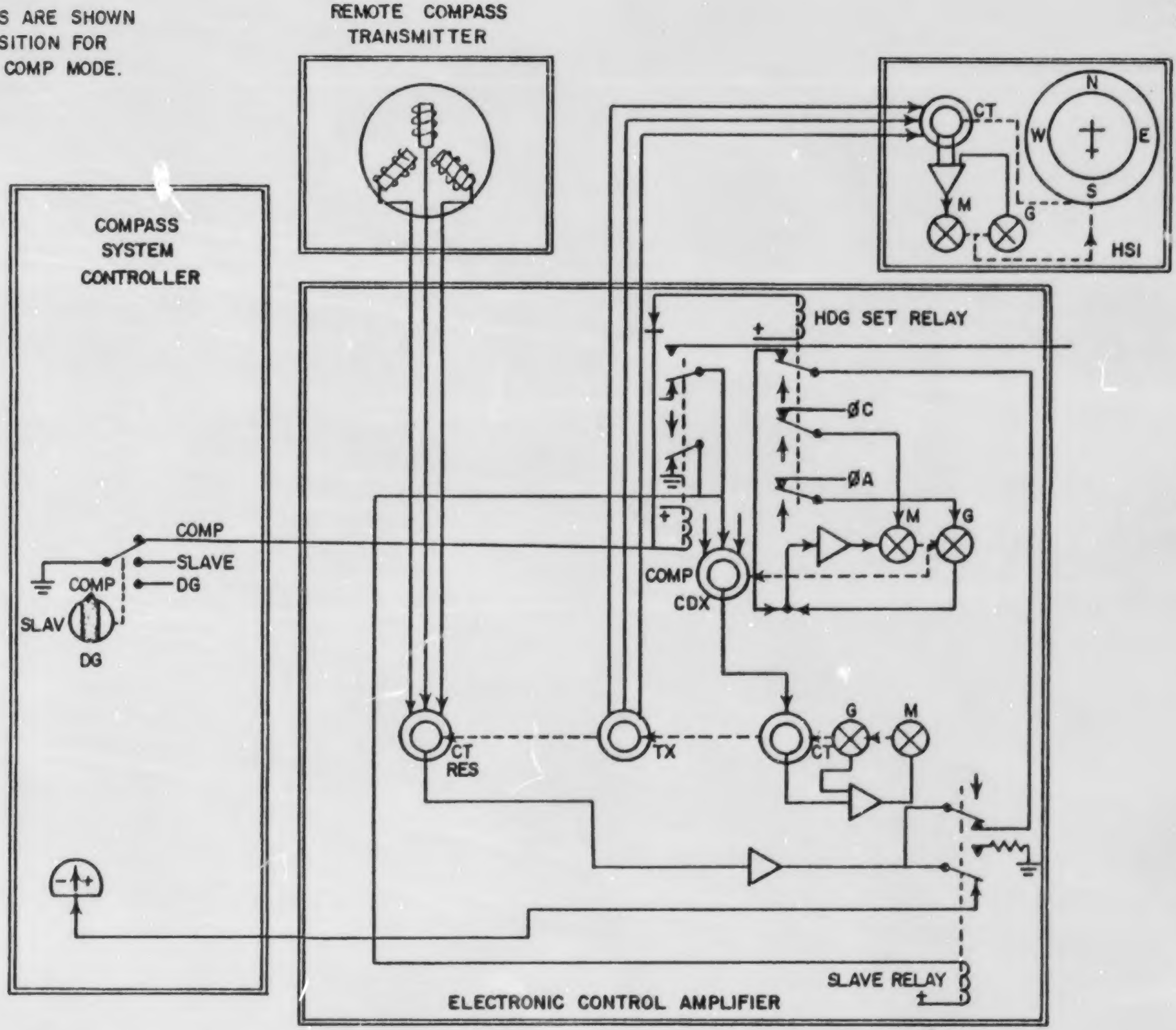
1864

1865

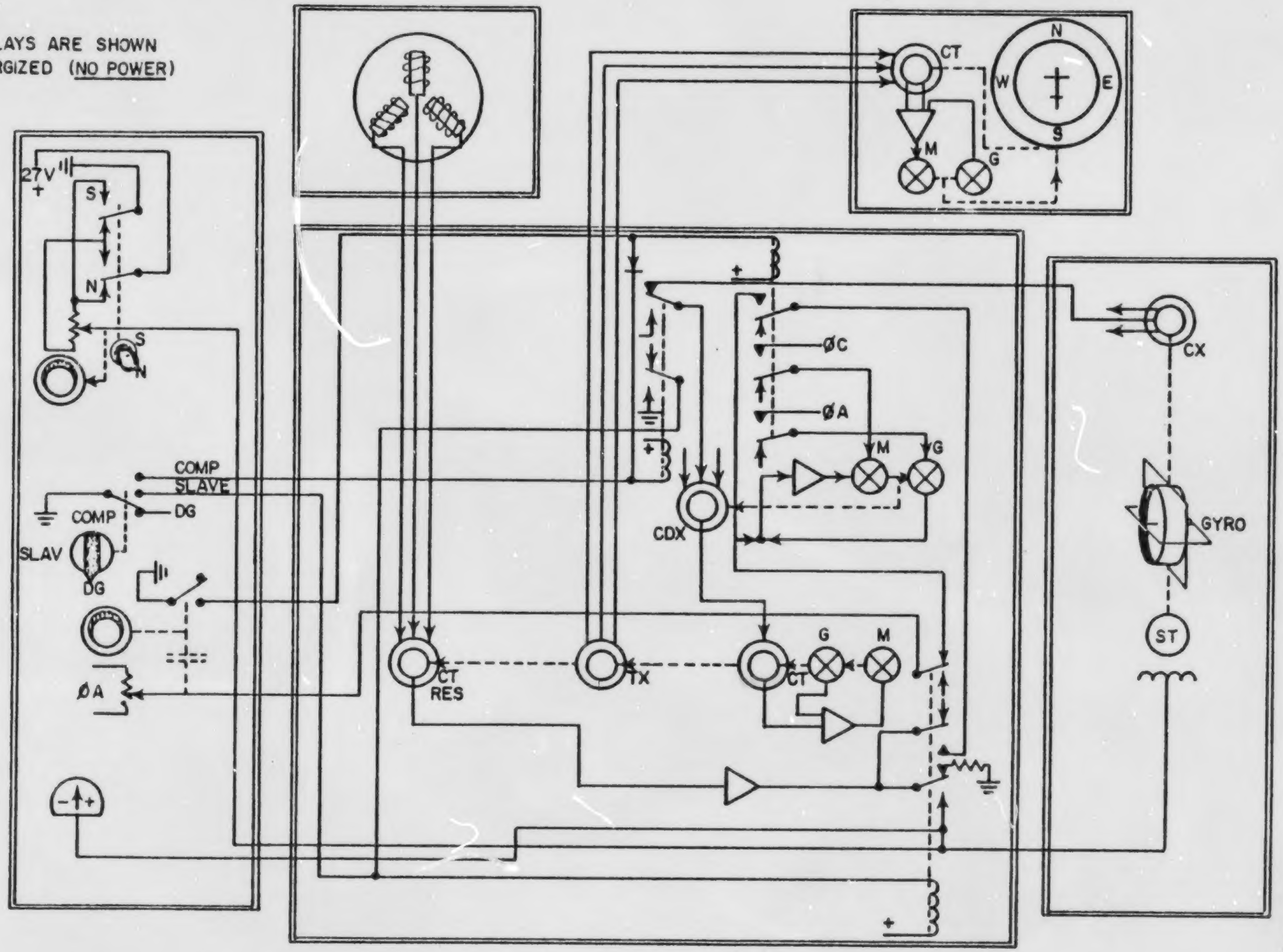

LEVEL FLIGHT - SENSING UNIT PARALLEL TO THE EARTH
SENSING UNIT CONTAINING PICK-UP COILS
BANK WITHOUT AIRCRAFT TURNING - SENSING UNIT PARALLEL TO THE EARTH
BANK WITH AIRCRAFT TURNING - SENSING UNIT PARALLEL TO THE AIRCRAFT WINGS

NOTE :

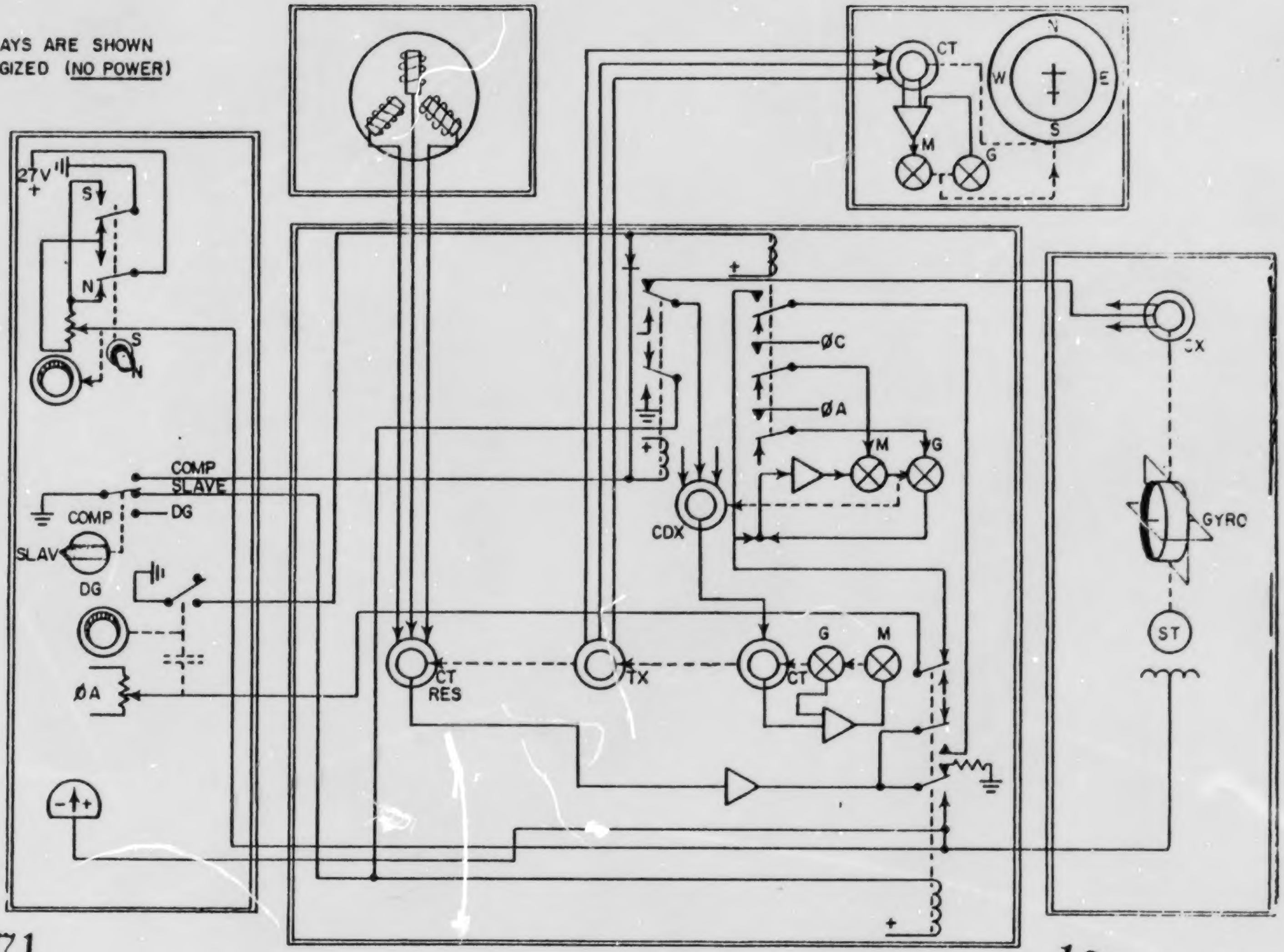
ALL RELAY CONTACTS ARE SHOWN IN THE PROPER POSITION FOR POWER ON IN THE COMP MODE.


REMOTE COMPASS TRANSMITTER
COMPASS SYSTEM CONTROLLER
COMP
SLAVE
DG
COMP
SLAV
DG
CT
N
W
E
S
M
G
HSI
HDG SET RELAY
ØC
ØA
M
G
COMP
CDX
CT
RES
TX
CT
G
M
SLAVE RELAY
ELECTRONIC CONTROL AMPLIFIER

NOTE :
ALL RELAYS ARE SHOWN
DE-ENERGIZED (NO POWER)


27V
+
S
N
S
N
COMP
SLAVE
DG
COMP
SLAV
DG
ØA
CT
N
W
E
S
M
G
+
+
ØC
ØA
M
G
CDX
CX
GYRO
ST
CT
RES
TX
CT
G
M
+

NOTE:
ALL RELAYS ARE SHOWN
DE-ENERGIZED (NO POWER)

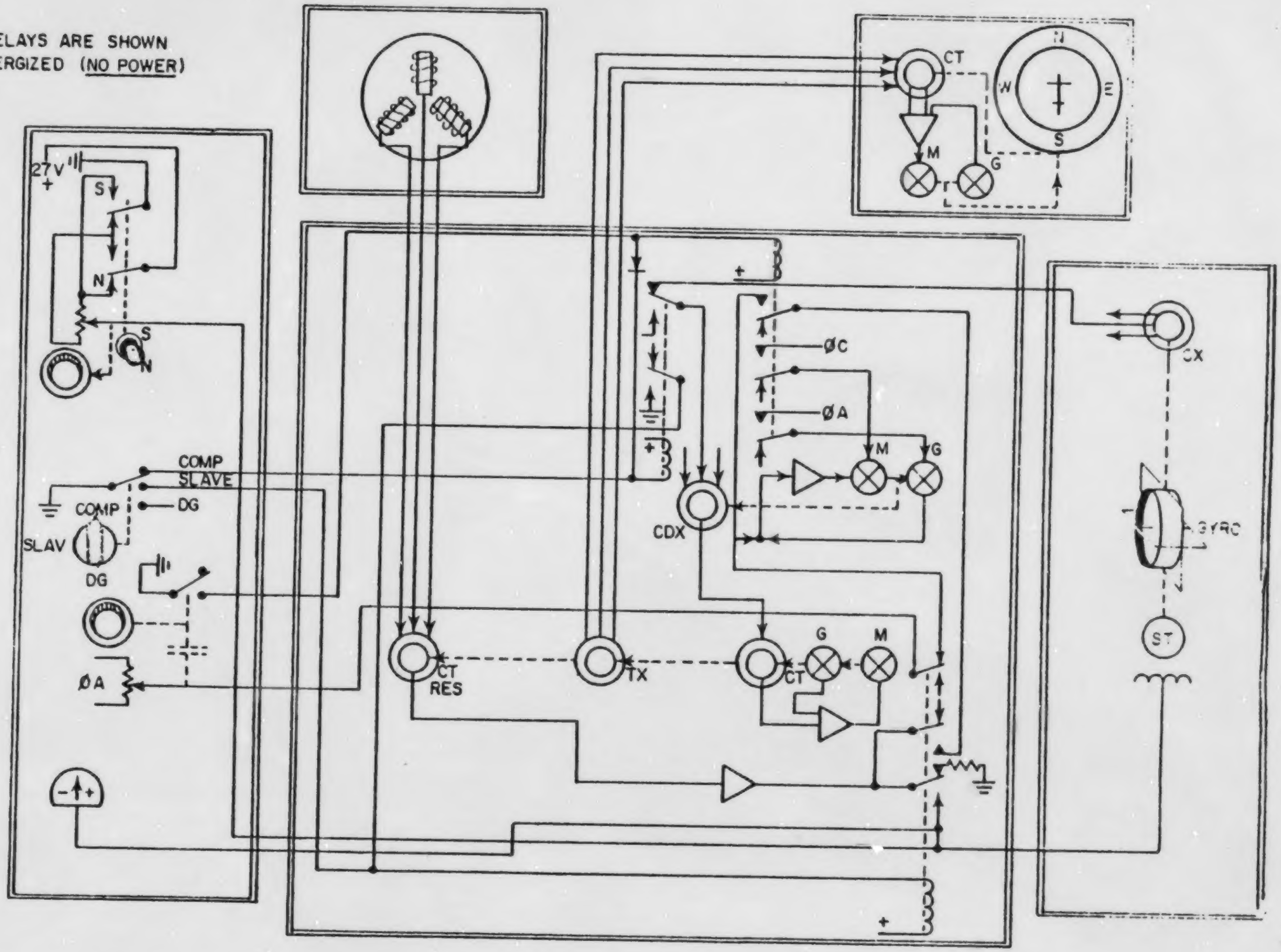

27V
+
S
N
S
N
COMP
SLAVE
DG
COMP
SLAV
DG
ØA
CT
N
W
E
S
M
G
+
ØC
ØA
M
G
+
CDX
CX
GYRO
ST
CT
RES
TX
CT
G
M
+

1871

1872

1788

NOTE :
ALL RELAYS ARE SHOWN
DE-ENERGIZED (NO POWER)



27V
S
N
S
N
COMP
SLAVE
DG
COMP
SLAV
DG
ØA
CT
N
W
E
S
M
G
ØC
ØA
M
G
CDX
CX
GYRO
ST
CT
RES
TX
CT
G
M

1873

1874

1789

1790

HANDOUT

3ABR32531-HO-403A
3ABR32632B-HO-502A

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

SCHEMATIC DIAGRAMS

13 July 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

73-25240

1875

FOREWORD

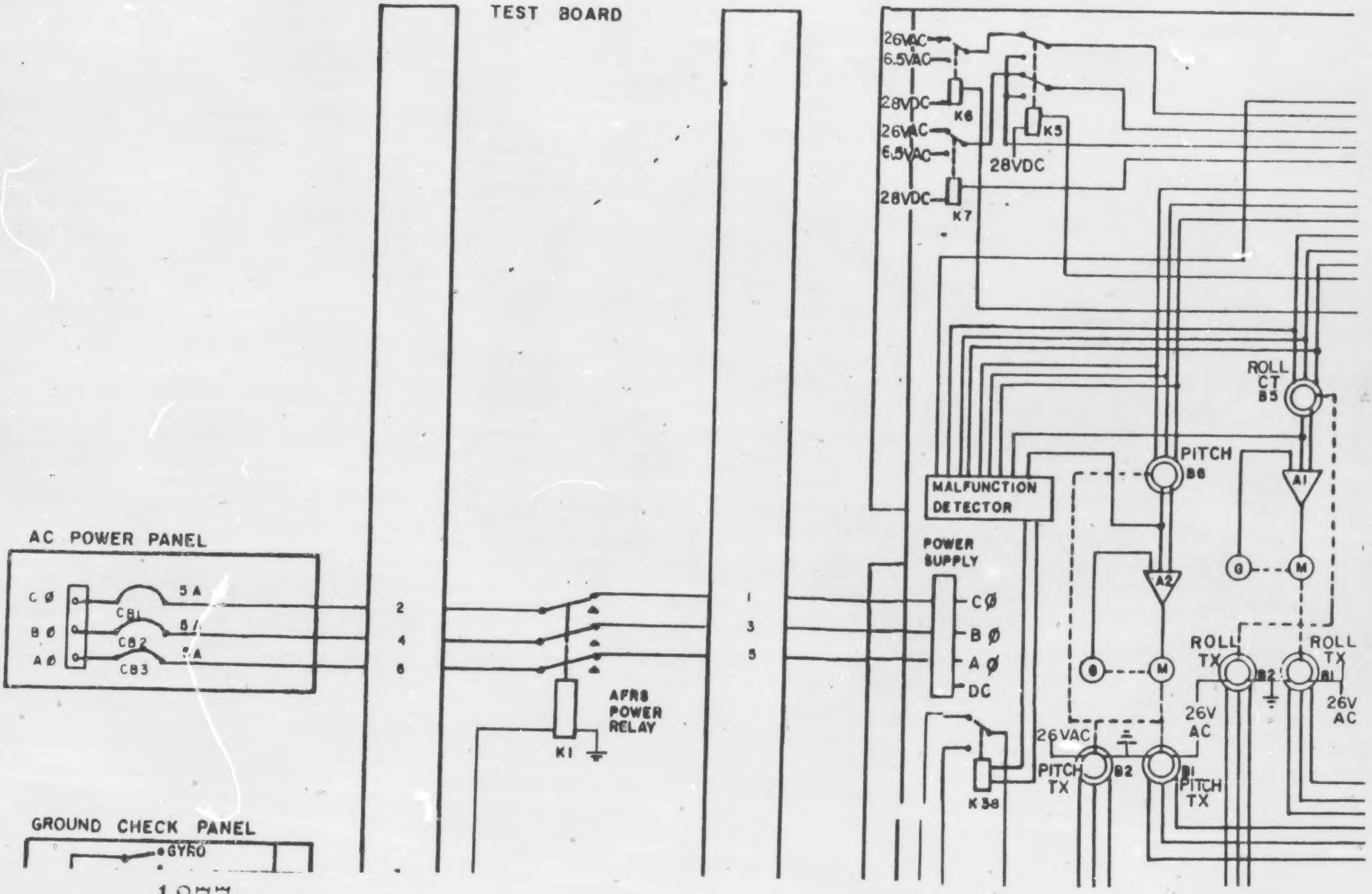
This handout was designed for use in Courses 3ABR32531, Avionics Instrument Systems Specialist and 3ABR32632B, Integrated Avionic Systems Specialist. This handout will be used in conjunction with 3ABR32531-PT-403 (3ABR32632B-PT-502B), AUXILIARY FLIGHT REFERENCE SYSTEM and with 3ABR32531-WB-403 (3ABR32632B-WB-502), AUXILIARY FLIGHT REFERENCE SYSTEM (Inspect, Operational Check and Troubleshooting) and will be used as directed by the programmed text, workbook and/or the instructor.

Supersedes 3ABR32531-HO-403A, 3ABR32632B-HO-405A, 6 March 1975;
3ABR32531-HO-404, 3ABR32632B-HO-405B, 29 August 1973.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 200; TTVSR - 1

AFRS ATTITUDE

Figure 1

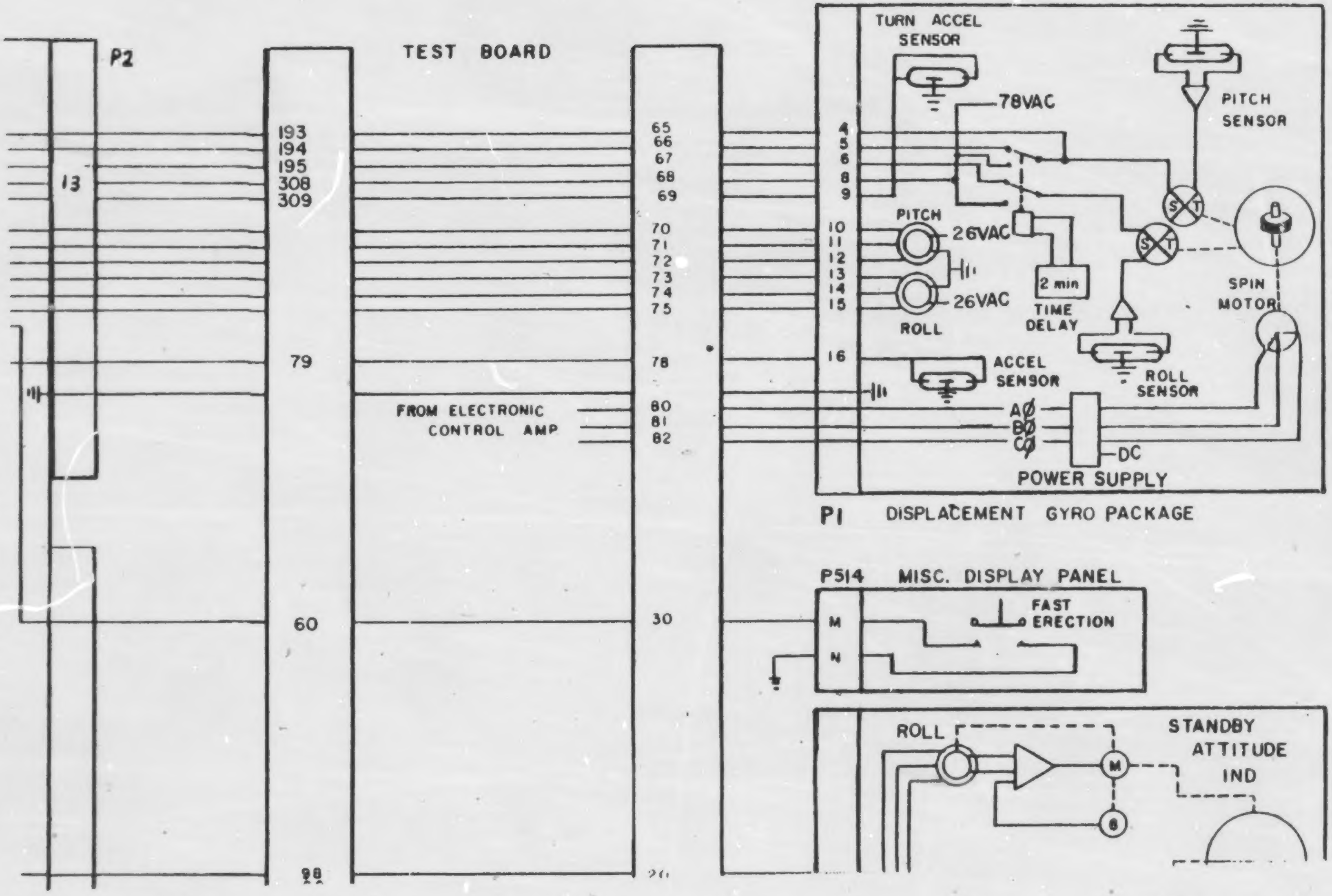
Section 1


TEST BOARD
26VAC
6.5VAC
28VDC
K6
K5
28VDC
26VAC
6.5VAC
28VDC
K7
ROLL CT B5
PITCH B6
MALFUNCTION DETECTOR
A1
A2
G
M
G
M
POWER SUPPLY
CØ
B Ø
A Ø
DC
ROLL TX
ROLL TX
B2
B1
26V AC
26V AC
26VAC
PITCH TX
B2
B1
PITCH TX
K 38
AC POWER PANEL
C Ø
B Ø
A Ø
CB1
CB2
CB3
5 A
5 A
5 A
2
4
6
1
3
5
AFRS POWER RELAY
K1
GROUND CHECK PANEL
GYRO

SYSTEM

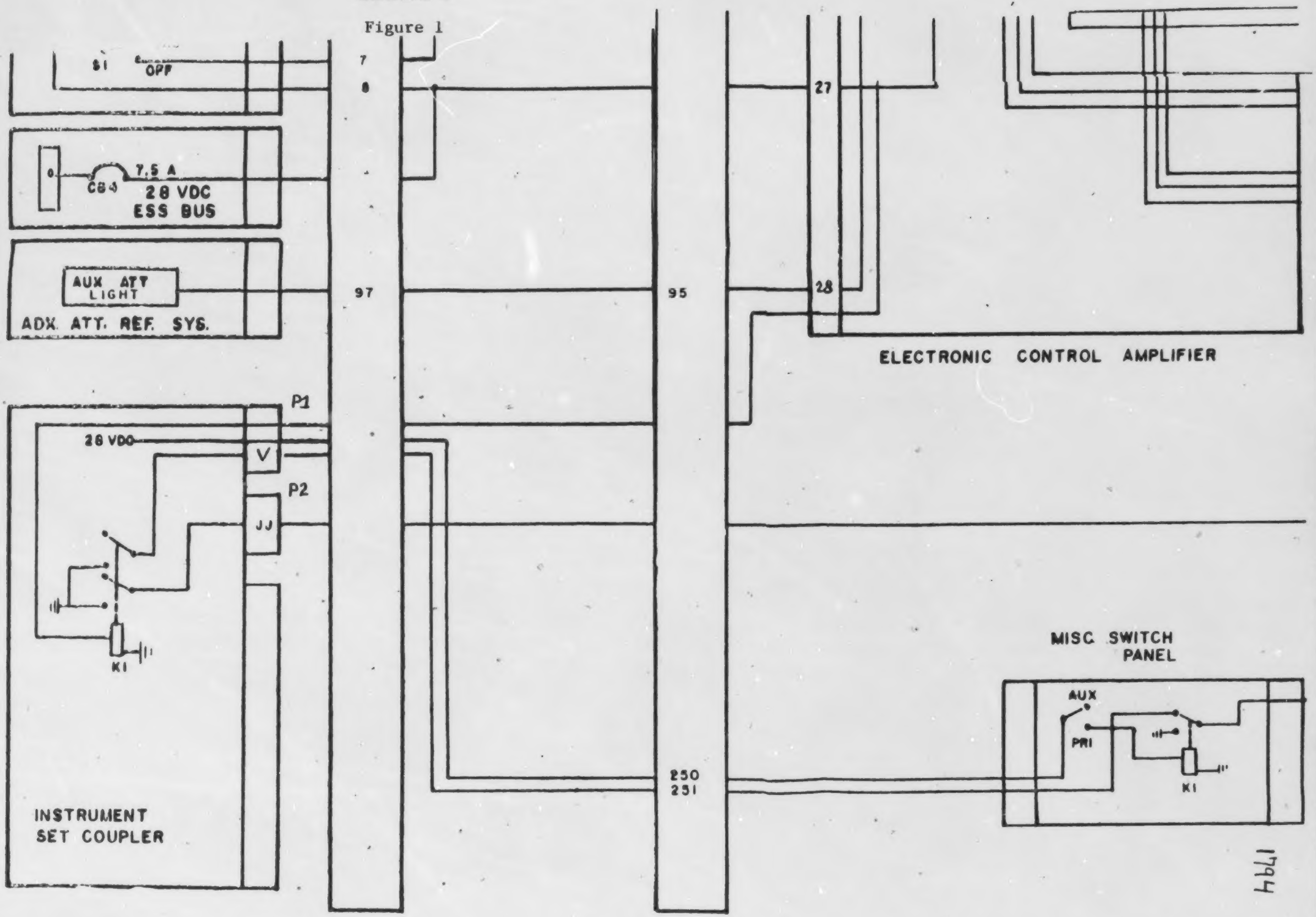
Section 2

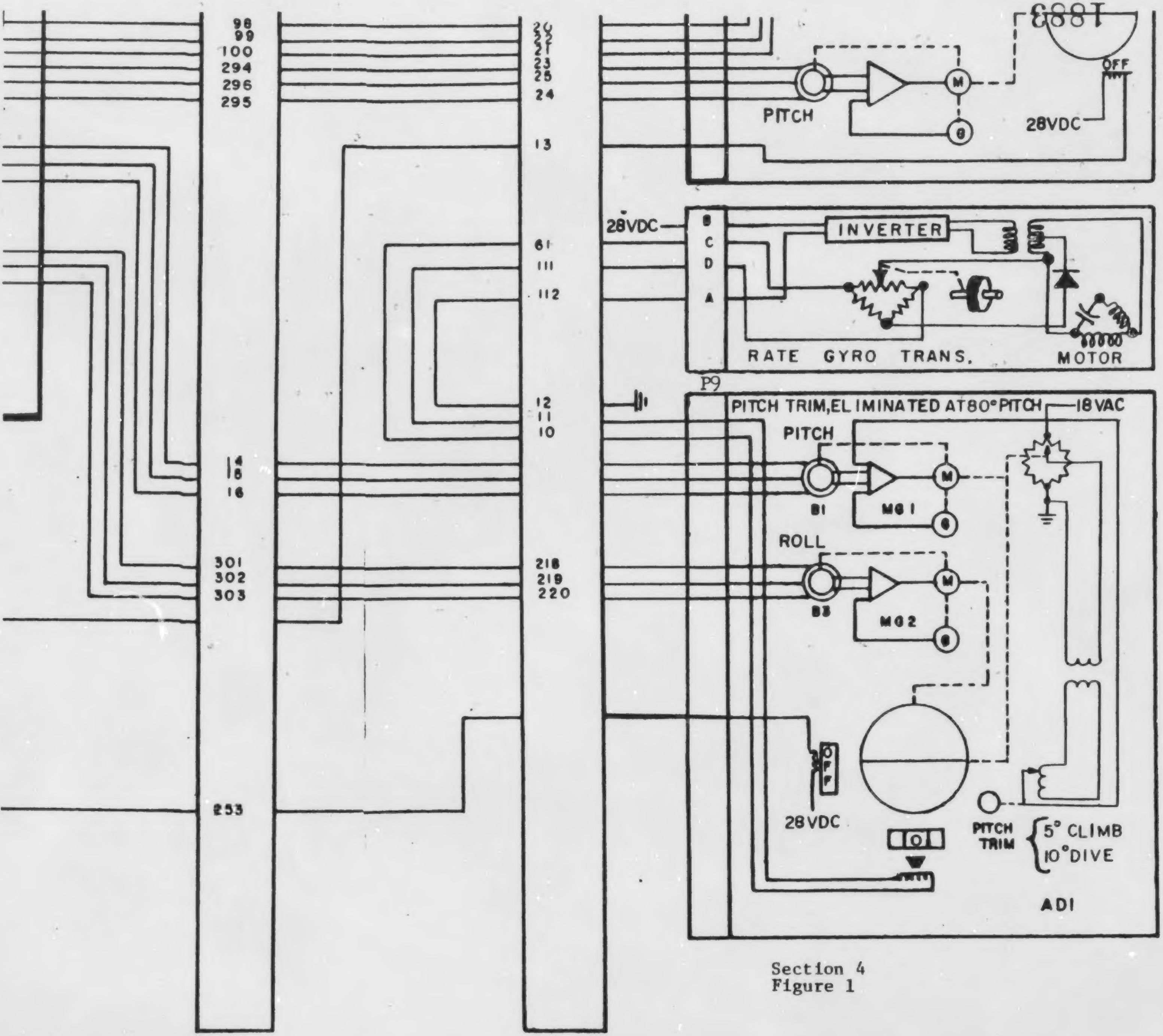
Figure 1


P2
13
TEST BOARD
193
194
195
308
309
79
60
98
65
66
67
68
69
70
71
72
73
74
75
78
80
81
82
30
FROM ELECTRONIC CONTROL AMP
TURN ACCEL SENSOR
78VAC
PITCH SENSOR
4
5
6
8
9
10
11
12
13
14
15
16
PITCH
26VAC
26VAC
ROLL
2 min
TIME DELAY
S
T
SPIN MOTOR
ACCEL SENSOR
ROLL SENSOR
AØ
BØ
CØ
DC
POWER SUPPLY
P1
DISPLACEMENT GYRO PACKAGE
P514
MISC. DISPLAY PANEL
M
N
FAST ERECTION
ROLL
STANDBY ATTITUDE IND
M
θ

Section 3

Figure 1


S1
OFF
7
8
CB4
7.5 A
28 VDC
ESS BUS
AUX ATT
LIGHT
ADX. ATT. REF. SYS.
97
95
27
28
ELECTRONIC CONTROL AMPLIFIER
P1
28 VDC
V
P2
JJ
K1
INSTRUMENT
SET COUPLER
250
251
MISC SWITCH
PANEL
AUX
PRI
K1


98
99
100
294
296
295
20
22
21
23
25
24
13
1884
1883
PITCH
OFF
28VDC
28VDC
B
C
D
A
INVERTER
RATE GYRO TRANS.
MOTOR
P9
61
111
112
12
11
10
PITCH TRIM, ELIMINATED AT 80° PITCH
18VAC
PITCH
B1
MG1
ROLL
B3
MG2
4
8
16
301
302
303
218
219
220
253
28VDC
OFF
PITCH TRIM
5° CLIMB
10° DIVE
ADI

Section 4
Figure 1

Figure 2, Section 1

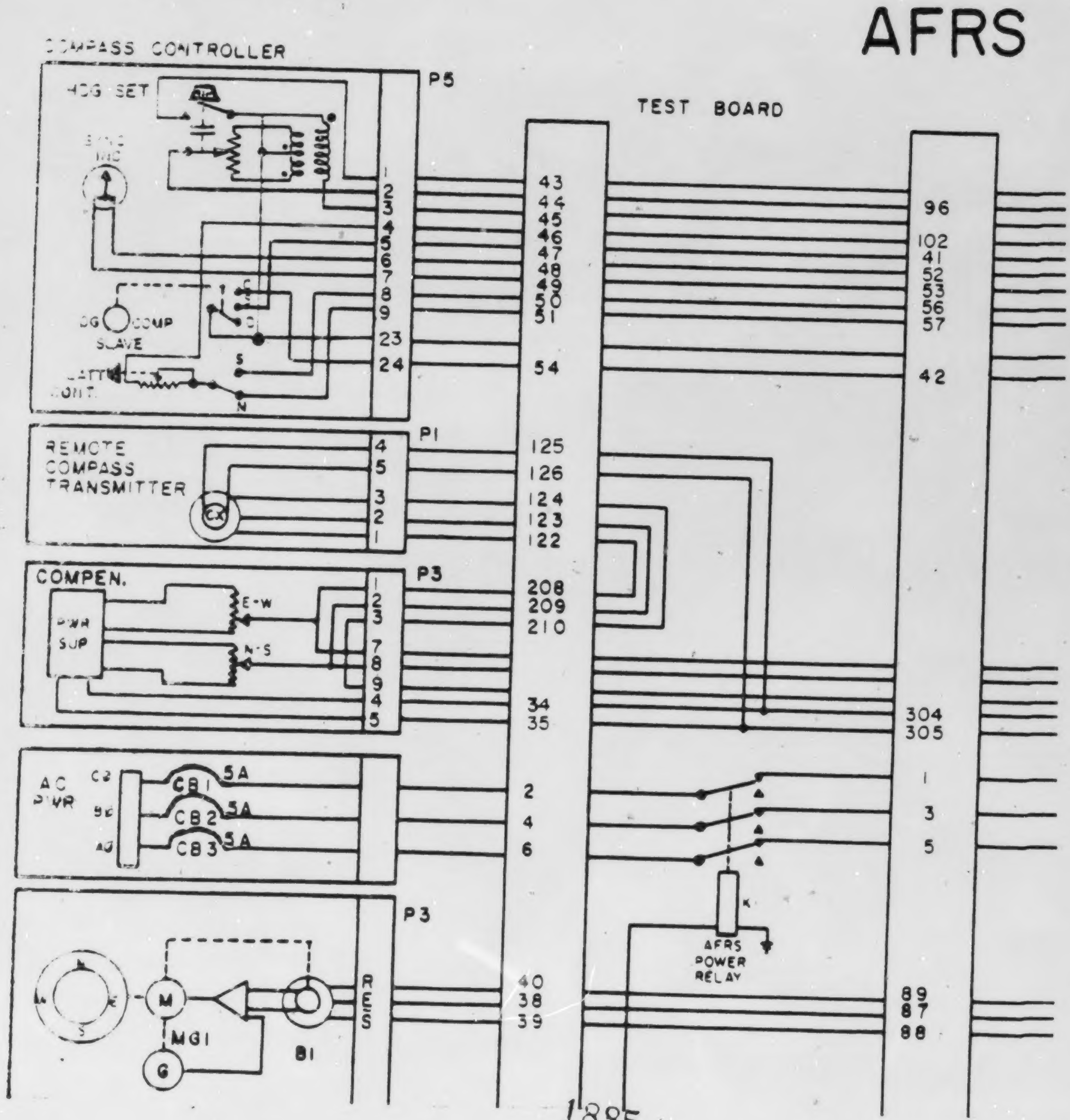
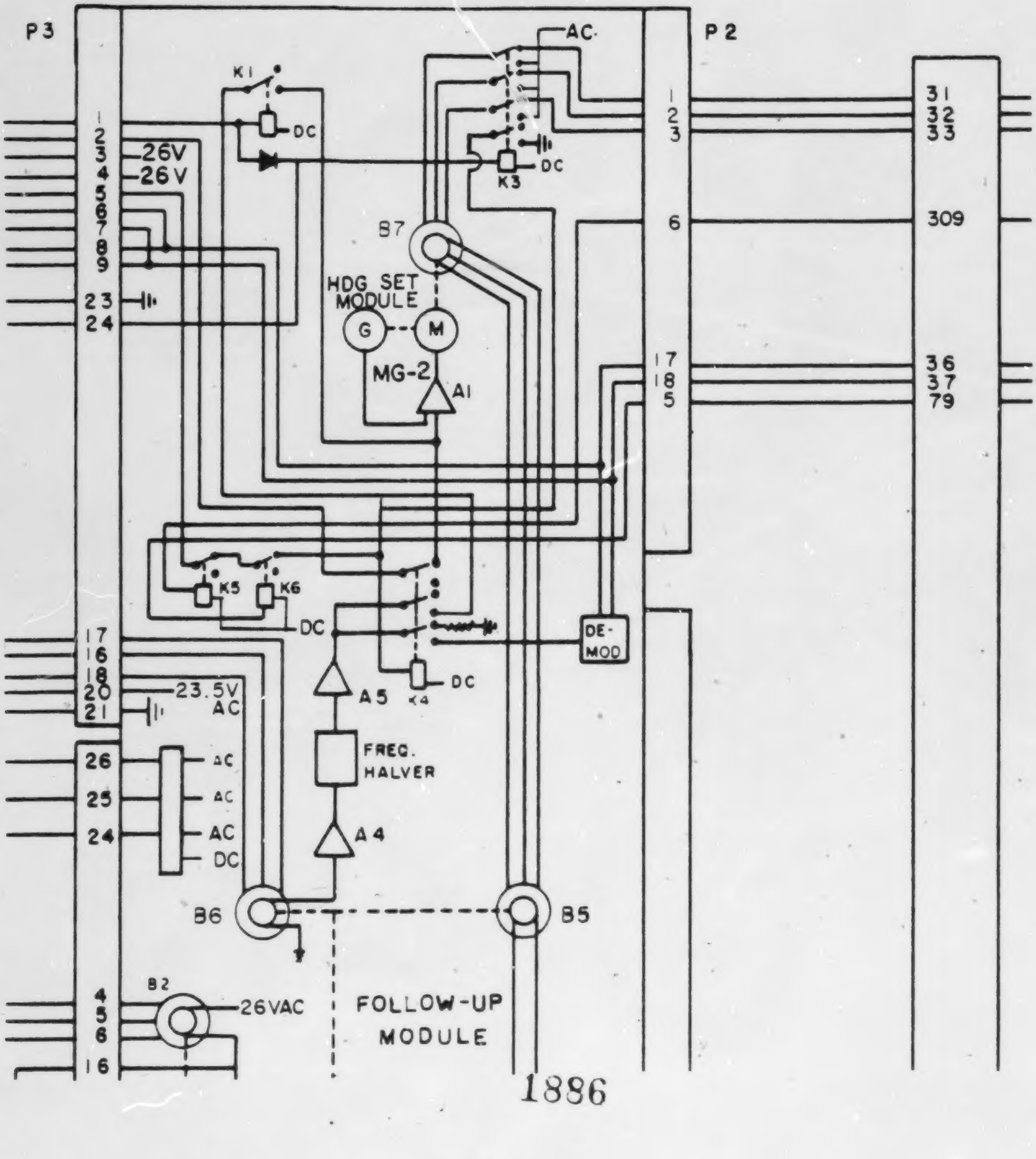

AFRS
COMPASS CONTROLLER
HDG SET
SYNC IND
DG COMP
SLAVE
LATT CONT
S
N
P5
1
2
3
4
5
6
7
8
9
23
24
TEST BOARD
43
44
45
46
47
48
49
50
51
54
96
102
41
52
53
56
57
42
REMOTE COMPASS TRANSMITTER
CX
P1
4
5
3
2
1
125
126
124
123
122
COMPEN.
PWR SUP
E-W
N-S
P3
1
2
3
7
8
9
4
5
208
209
210
34
35
304
305
AC PWR
CB1
CB2
CB3
5A
5A
5A
2
4
6
1
3
5
K
AFRS POWER RELAY
P3
M
MG1
G
B1
RES
RES
40
38
39
89
87
88

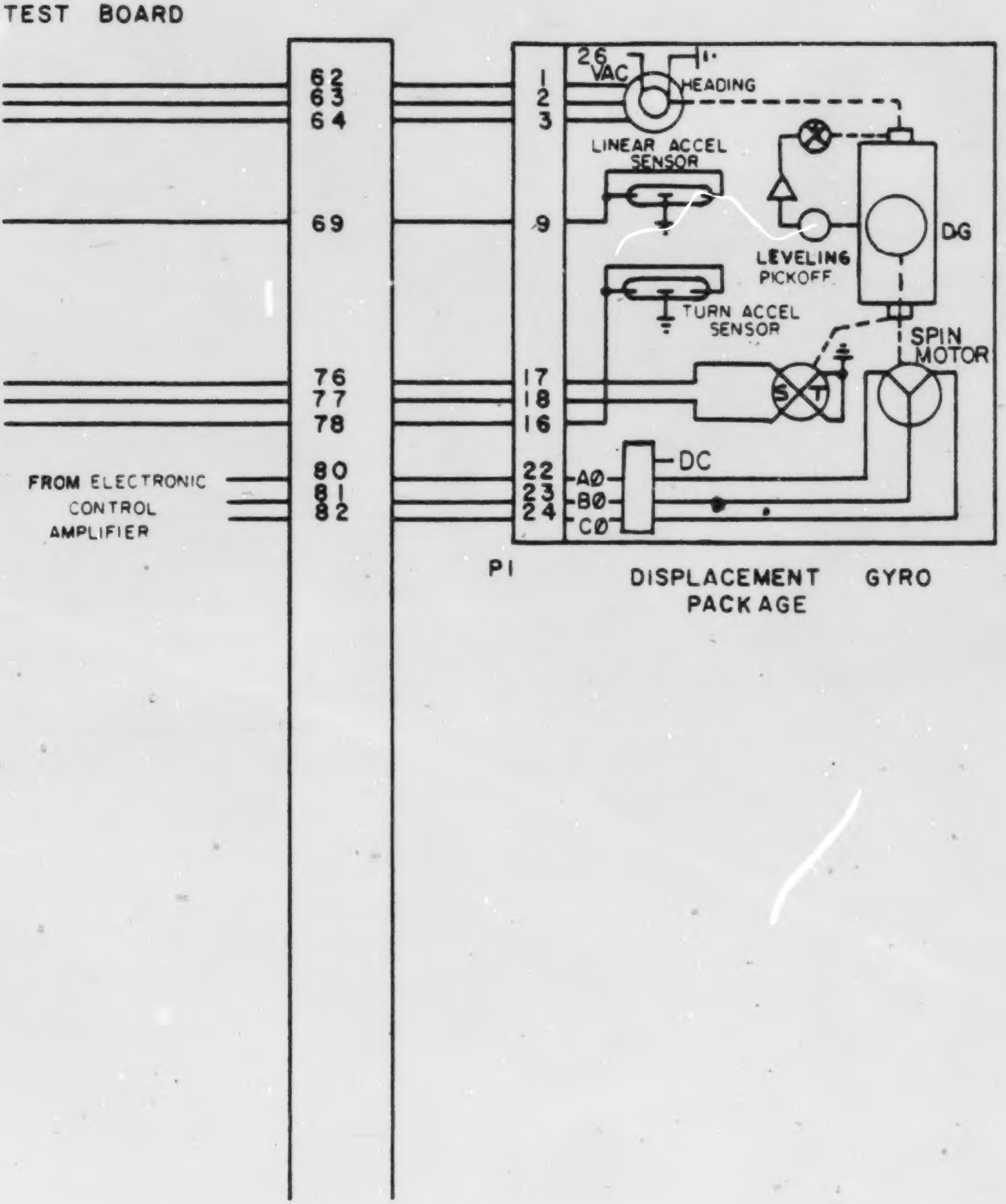
Figure 2, Section 2

COMPASS SYSTEM



P3
P2
K1
DC
K3
AC
B7
HDG SET MODULE
G
M
MG-2
A1
26V
26V
23.5V AC
K5
K6
K4
DE-MOD
A5
FREQ. HALVER
A4
B6
B5
B2
26VAC
FOLLOW-UP MODULE
1
2
3
4
5
6
7
8
9
23
24
17
16
18
20
21
26
25
24
4
5
6
16
1
2
3
6
17
18
5
31
32
33
309
36
37
79

Figure 2, Section 3


TEST BOARD
62
63
64
69
76
77
78
80
81
82
FROM ELECTRONIC CONTROL AMPLIFIER
1
2
3
9
17
18
16
22
23
24
P1
26 VAC
HEADING
LINEAR ACCEL SENSOR
LEVELING PICKOFF
DG
TURN ACCEL SENSOR
SPIN MOTOR
S
T
DC
A0
B0
C0
DISPLACEMENT GYRO PACKAGE

1799

Figure 2, Section 4

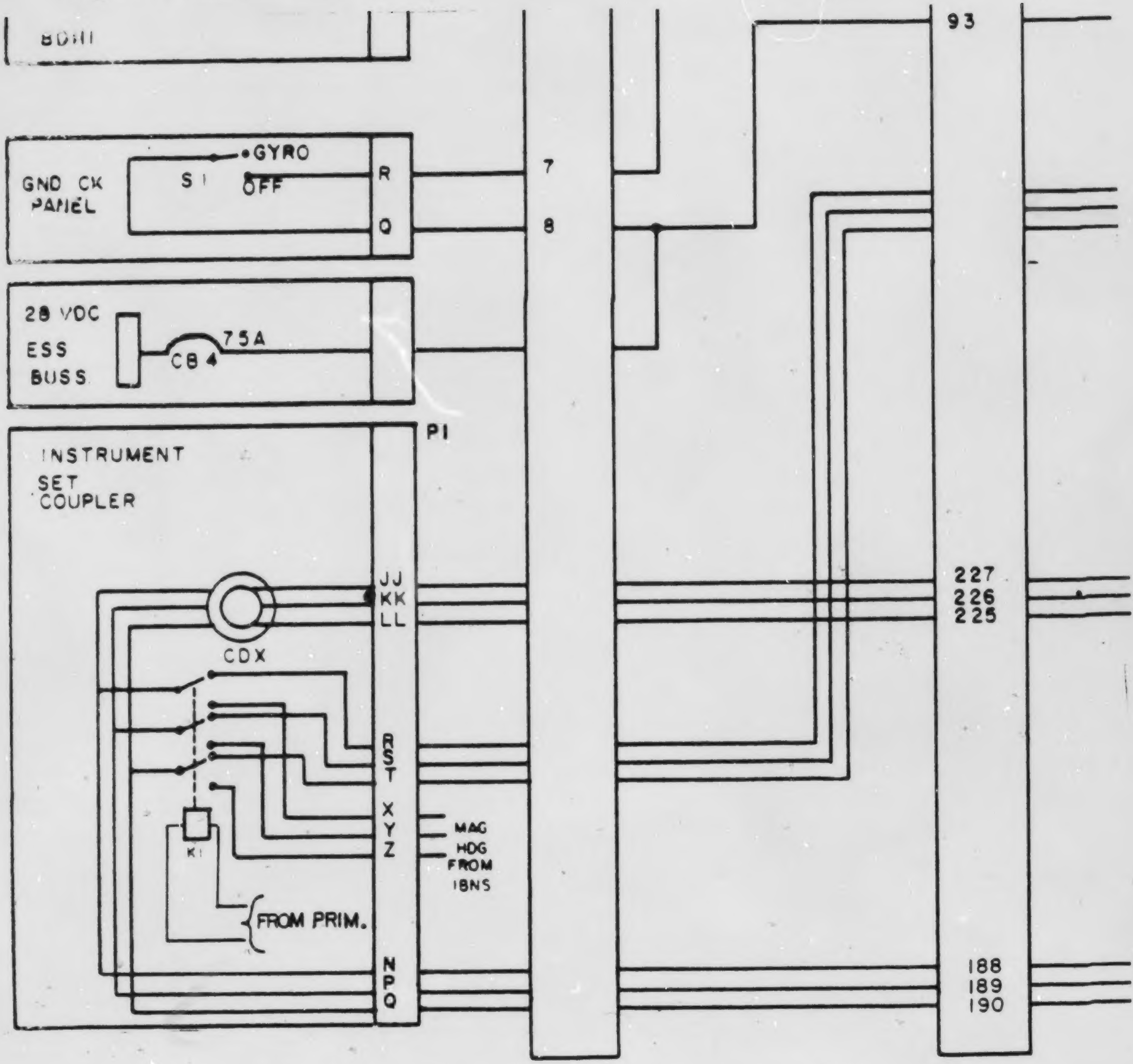
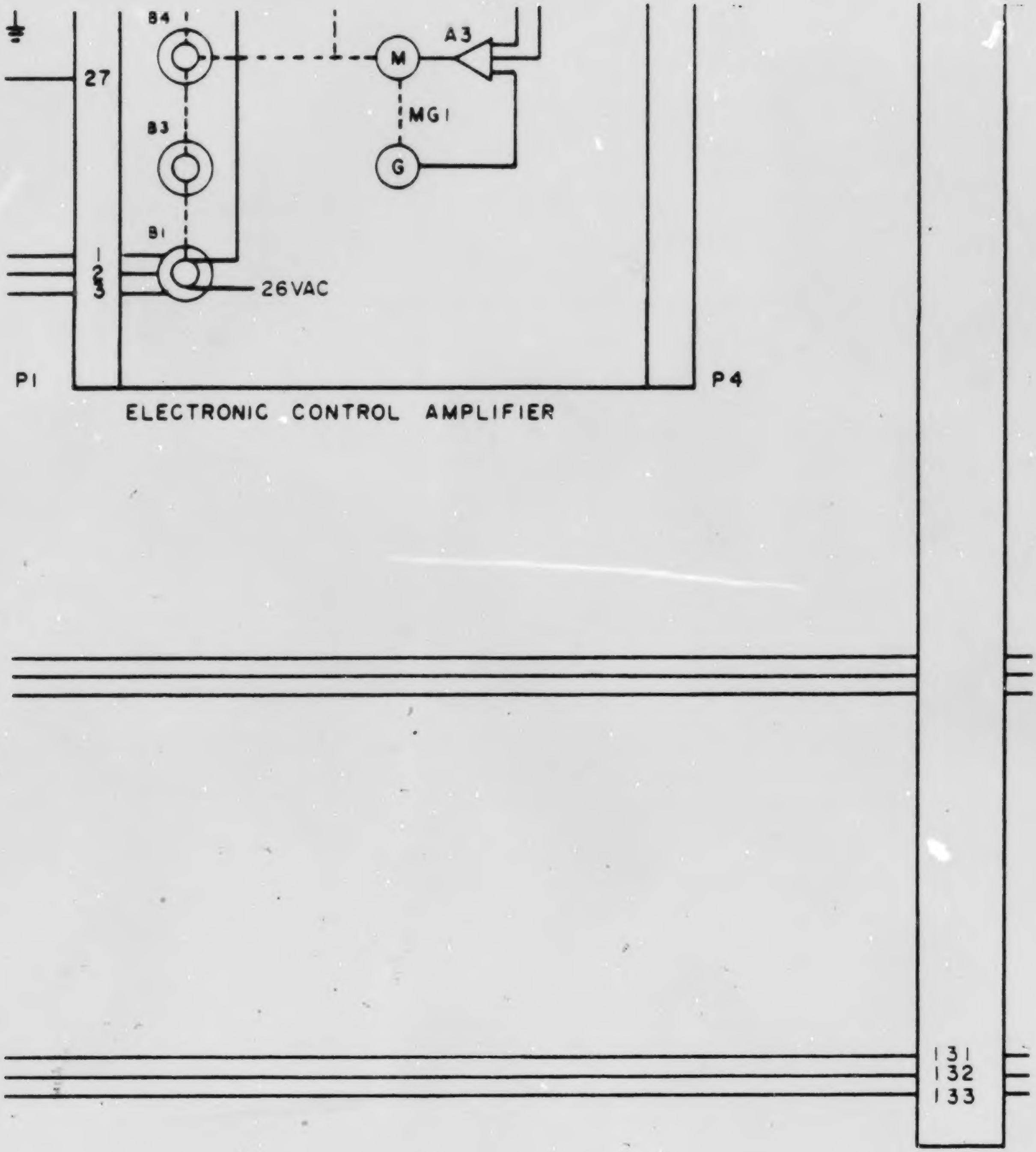
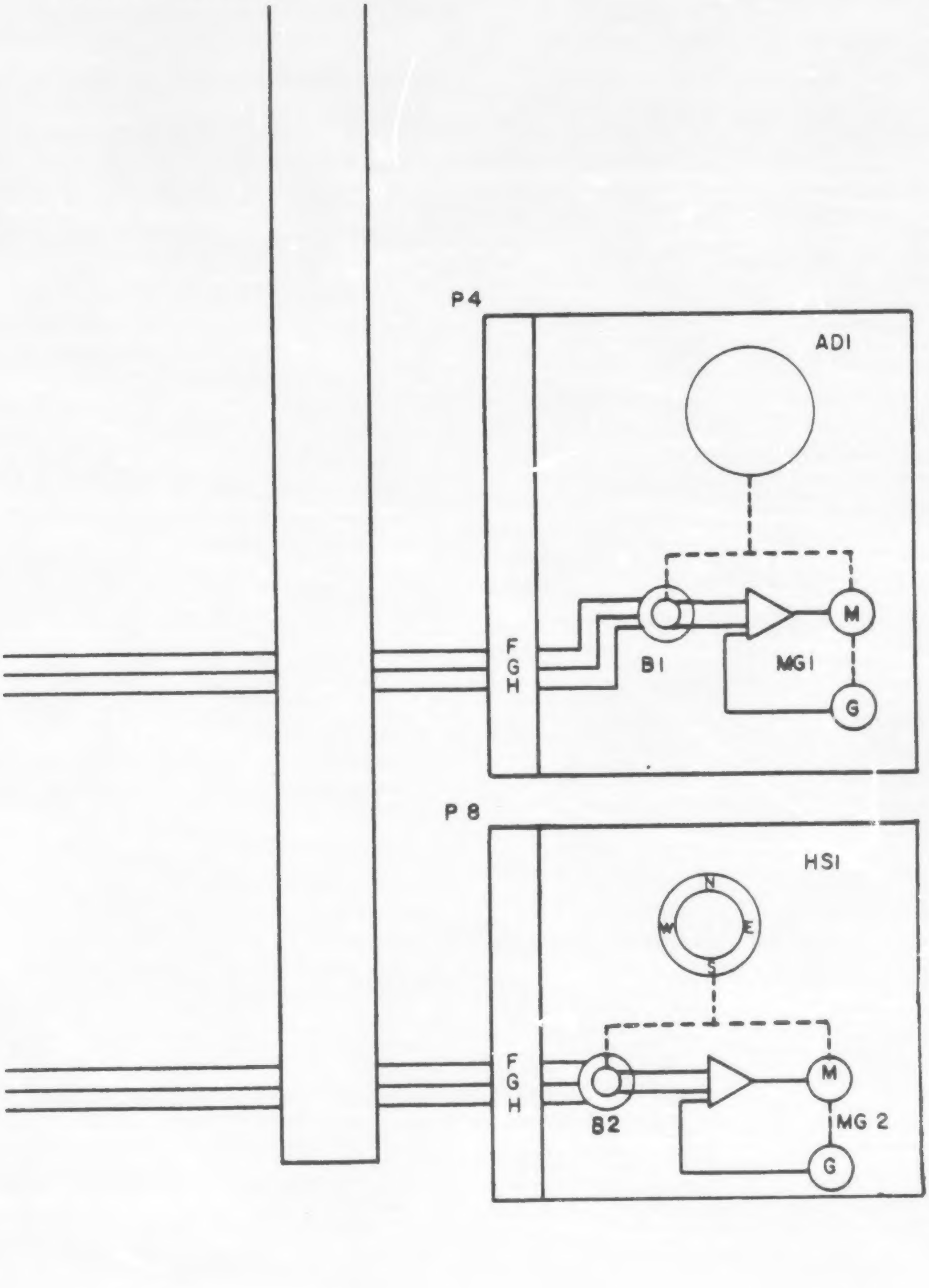

BDHI
GND CK PANEL
S1
GYRO
OFF
R
Q
7
8
93
28 VDC ESS BUSS
CB 4
7.5A
INSTRUMENT SET COUPLER
P1
JJ
KK
LL
CDX
R
S
T
X
Y
Z
MAG HDG FROM IBNS
K1
FROM PRIM.
N
P
Q
227
226
225
188
189
190

Figure 2, Section 5


B4
A3
M
MG1
27
B3
G
B1
1
2
3
26VAC
P1
P4
ELECTRONIC CONTROL AMPLIFIER
131
132
133

1801

Figure 2, Section 6


P4
ADI
F
G
H
B1
MG1
M
G
P8
HSI
N
W
E
S
F
G
H
B2
MG 2
M
G

1802

WORKBOOK

3ABR32531-WB-403~~A~~

Technical Training

Avionics Instrument Systems Specialist

ATTITUDE HEADING REFERENCE AND GYRO STABILIZED MAGNETIC COMPASS SYSTEMS

2 June 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

1891

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-403A

BENCH CHECK AFRS SYSTEM ELECTRONIC COMPONENTS

OBJECTIVE

Given a workbook, test equipment, technical data and trainer, bench check representative components of the attitude-heading reference system with a minimum of 80% accurate workbook responses.

INSTRUCTIONS

This workbook is to be used in conjunction with programmed text 3ABR32531-PT-403A, ELECTRONIC TEST EQUIPMENT.

This workbook is divided into four (4) sections with each section containing the necessary instructions for bench checking one (1) component of the attitude-heading reference system. At the beginning of each section you will be issued a technical order and be referred to the specific steps needed to complete the bench check in that section. Follow the technical order steps unless directed otherwise by your instructor. If ANY step is not clear to you, check with your instructor before proceeding. DO NOT RUSH!

SECTION A

BENCH CHECK OF THE AMPLIFIER POWER SUPPLY

EQUIPMENT

	Basis of Issue
AJM-17	1/student
Oscilloscope	1/student
Phase Angle Voltmeter	1/student
DC Digital Voltmeter	1/student
PSM-6	1/student
Amplifier Power Supply	1/student
Workbook	1/student
TO 5A1-9-2-2	1/student

PROCEDURE

Turn to Section 10 in the TO. Follow the procedures step-by-step completing all sections required. Record your results in the spaces provided in this workbook. This workbook will be checked by the instructor. Remove your jewelry.

Supersedes 3ABR32531-WB-403A, 21 April 1975; 3ABR32531-WB-403B, 27 March 1974; 3ABR32531-WB-403C, 27 March 1974; 3ABR32531-WB-403D, 9 January 1975.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 250; TTVSR - 1

Inspection

Preliminary Operation Instructions. (Refer to TO paragraph 10-2.)

1. In the spaces following, list any damage or corrosion found during the visual inspection. ____

____

2. No response required.

3. No response required.

4. No response required.

5. Time totalizing operation.

Sat __________ Unsat __________

POWER ON lamp.

Sat __________ Unsat __________

6. No response required.

7. Use table 1 below.

VOLTAGE READINGS		SAT	UNSAT
ØA			
ØB			
ØC			

Table 1.

Bench Check

Resistance Continuity. (Refer to TO paragraph 10-3.)

1. Place resistance continuity switch in each of the positions indicated in table 2 and monitor output on multimeter.

1805

RESISTANCE CONTINUITY (switch position)	MULTIMETER INDICATION (ohms)	SAT	UNSAT
1			
2			
3			
4			
5			
6			
7			
8			
OFF			

Table 2. Resistance Continuity Test.

Voltage Continuity. (Refer to TO paragraph 10-4.)

1. Place voltage continuity switch in position 11. Wait 2 (two) minutes, then proceed with TO table 10-3. DO NOT PERFORM TEST 1 THROUGH 10.

VOLTAGE CONTINUITY (switch pos.)	MULTIMETER READING (ohms)	D-C VTVM READING (VDC)	A-C VTVM READING (VAC)	PHASE REFERENCE Dial Reading* (degrees)
11				
12		■		
13		■		
14	■			
15		■		
16	■	■		
17		■	■	■

*Adjust phase reference control until an inphase pattern on the oscilloscope and note phase reference dial indication.

Table 3. Voltage Continuity Test.

1894

a. Circle unsatisfactory readings in table 3.

Erection Cutout and Fast Erection. (Refer to TO paragraph 10-5.)

1. Place switches in positions indicated in table 4 and monitor output.

a. Circle unsatisfactory readings in table 4.

Power Interruption. (Refer to TO paragraph 10-6.)

1. No response required.

2. No response required.

3. Reading __________. Sat __________ Unsat __________

Power Failure Warning. (Refer to TO paragraph 10-7.)

1. Multimeter Reading __________. Sat ________ Unsat ________

a. AC VTVM Reading ________. Sat ________ Unsat ________

AMPLIFIER-ERECTION (switch pos.)	ERECTION (switch pos.)	FAST ERECTION (switch pos.)	A-C VTVM readings (VAC)
1	NORMAL	NORMAL	
1	NORMAL	FAST	
1	ROLL CUTOUT	FAST	
1	ROLL CUTOUT	NORMAL	
2	NORMAL	NORMAL	
2	NORMAL	FAST	
2	PITCH CUTOUT	FAST	
2	PITCH CUTOUT	NORMAL	

Table 4. Erection Cutout and Fast Erection Test.

2. Multimeter Reading __________. Sat ________ Unsat ________

3. Multimeter Reading __________. Sat ________ Unsat ________

4. No response required.

Leveling Pickoff Excitation. (Refer to TO paragraph 10-8.)

1. AC VTVM Reading _________. Sat ________ Unsat ________

DO NOT PERFORM paragraphs 10-9, 10-10, and 10-11.

Roll Servoalarm. (Refer to TO paragraph 10-12.)

1. No response required.

Caution: PLACE THE ACVM RANGE SELECTOR TO THE 1V RANGE!!!

2. Multimeter Reading _________. Sat ________ Unsat ________

Caution: PLACE THE ACVM RANGE SELECTOR TO THE 300V RANGE!!!

3. Multimeter Reading _________. Sat ________ Unsat ________

4. Multimeter Reading _________. Sat ________ Unsat ________

5. Multimeter Reading _________. Sat ________ Unsat ________

Pitch Servoalarm. (Refer to TO paragraph 10-13.)

1. Multimeter Reading _________. Sat ________ Unsat ________

2. Multimeter Reading _________. Sat ________ Unsat ________

Conclusion of Testing. (Refer to TO paragraph 10-14.)

1. No response required.

2. No response required.

3. No response required.

4. Position switches and controls, remove power and disconnect associated test equipment from test panel according to procedure inapplicable test equipment operating instructions.

5. Have your instructor check your workbook.

6, Replace dust covers on equipment.

7. Replace components in storage.

SECTION B

BENCH CHECK RATE OF TURN GYRO TRANSMITTER

EQUIPMENT

	Basis of Issue
Rate-of-Turn Gyro Transmitter	1/student
Rate Table	1/student
AJM-17 Test Set	1/student
Digital DC Voltmeter	1/student
TO 5A1-9-2-2	1/student
Workbook	1/student

PROCEDURES

Turn to page 8-1 in TO 5A1-9-2-2, MAINTENANCE INSTRUCTIONS FOR THE RATE-OF-TURN GYRO TRANSMITTER. Follow the instructions exactly as they are given. Record your results in the spaces provided in this workbook. Answer questions in this workbook and indicate if the checks are satisfactory or unsatisfactory in the spaces provided. This workbook will be checked by your instructor. Remove your jewelry.

INSPECTION

1. Preliminary Checks (TO para 8-2).

a. Make a visual inspection as per TO instructions.

b. List any damages or corrosion found during the visual inspection.

____

____

____

c. Position the Rate Gyro Transmitter Test Panel (AJM-17) controls and switches as indicated in table 8-1 in the TO.

d. Connect bench test set-up in accordance with figure 8-1 as in the TO.

BENCH CHECK

1. Power Consumption Test (TO para 8-3).

   a. The highest reading within 5 seconds was _____ ma.

   Check is satisfactory _____ unsatisfactory _____.

   b. X26 position _____ milliamperes.

   Check is satisfactory _____ unsatisfactory _____

   c. X115 position _____ milliamperes.

   Check is satisfactory _____ unsatisfactory _____

   d. Circle the correct answer below.

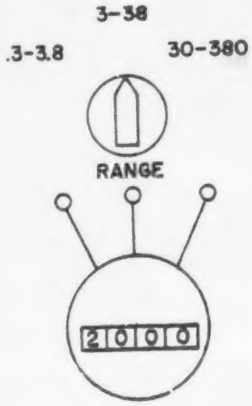
With the RANGE switch and RATE SET potentiometer set as shown by the figure below, what is the rate of turn?

(1) 2 degrees per min.

(2) 20 degrees per min.

(3) 200 degrees per min.

(4) 2000 degrees per min.



2. Output Sensitivity and Null Limits Check (TO para 8-4).

   a. Indication of the DC VTVM with rate table in "stop" is ______________.

   Satisfactory _____ Unsatisfactory _____

b. Complete the following table for the DC VTVM readings indicating if each check is satisfactory or unsatisfactory.

RATE SET Control Setting	ROTATION Switch Position	D-C Vtvm Indication	SAT	UNSAT
045.0 (45° per min)	CW			
090.0 (90° per min)	CW			
180.0 (180° per min)	CW			
360.0 (360° per min)	CW			
Place rate table power switch in off position. Place rotation switch in CCW position. Return rate table power switch to on position.				
360.0 (360° per min)	CCW			
180.0 (180° per min)	CCW			
090.0 (90° per min)	CCW			
045.0 (45° per min)	CCW			

(Omit TO paragraphs 8-5, 8-6, and 8-7.)

3. Conclusion of Testing (TO para 8-8).

a. After completion of para 8-8, have the instruction check your workbook.

b. Replace dust caps on equipment as required.

c. Replace the components in storage.

SECTION C

BENCH CHECK SWITCHING RATE GYRO

EQUIPMENT

	Basis of Issue
AJM-17 Test Set	1/student
Switching Rate Gyro	1/student
Rate Table	1/student
Electronic Counter	1/student
Workbook	1/student
TO 5A1-9-2-2	1/student

PROCEDURE

The TO and workbook provide the operational instructions necessary for operating the AJM-17 test set when bench checking the switching rate gyro. Follow the instructions carefully. Spaces are provided for recording the results of each check. This workbook will be checked by the instructor. Remove all jewelry.

INSPECTION

1. Preliminary Checks. (TO para. 16-2)

a. Make a visual inspection as per TO instructions.

b. List in the spaces below, any damage or corrosion found.

(1) ____.

(2) ____.

(3) ____.

c. Position the switching rate gyro test panel (AJM-17) controls and switches as indicated in table 16-1 in the TO.

d. Connect bench test set-up in accordance with figure 16-1 in the TO.

Caution: The RATE SET control is offset from zero. Do not turn it counterclockwise below a setting of 0150 or clockwise above a setting of 3850. The calibration and accuracy of the RATE SET control can be destroyed by forcing it against its potentiometer stops.

Do not change the position of the ROTATION switch without first placing the rate table POWER switch in the OFF position.

Keep the cable assembly from becoming entangled during rate table operation. Excessive drag may result in invalid test results and equipment damage.

e. Position the rate table switches and controls as indicated in table 16-2.

f. Position electronic counter switches and controls as indicated in tables 1a or 1b. Table 1a contains the settings for the Hewlett Packard counter. Table 1b contains the settings for the Eldorado counter.

Switch or Control	Position
TRIGGER SLOPE START switch	+
TRIGGER SLOPE STOP switch	-
INPUTS switch	COMMON
TRIGGER LEVEL START control	X10 and 2 (DC)
TRIGGER LEVEL STOP control	X10 and 2 (DC)
FUNCTION SELECTOR switch	TIME INTERVAL
TIME UNIT switch	SEC
POWER switch	ON

Table 1a.

Switch or Control	Position
POWER switch	ON
STORAGE	OFF
DISPLAY	C/W
RESET	Press to clear display
MODE	AX 1
TIME	10.5
INPUTS	X 1
CIRCUIT switches	DC
SLOPE A	-
SLOPE B	+

Table 1b.

BENCH CHECK

1. Power Consumption Test. (TO para. 16-3)

a. Results of GYRO NORMAL and POWER lamps check.

Sat_____. Unsat_____.

b. Results of Power Consumption Test. Sat_____. Unsat_____.

2. Switching Rate Test. (TO para. 16-4)

a. Adjust the rate table for direction and rotational speed as specified in the TO. Record time and results of the test.

Control Setting	Rotation	Time Interval for switching (max seconds)	Actual Time interval	Results	
				S	U
15°/Min.	CW	30			
20°/Min.	CW	20			
45°/Min.	CW	8			
180°/Min.	CW	4			
Place rate table POWER switch in OFF position. Place rate table ROTATION switch in CCW position. Return rate table POWER switch to ON position.					
180°/Min.	CCW	4			
45°/Min.	CCW	8			
20°/Min.	CCW	20			
15°/Min.	CCW	30			

b. At the conclusion of step a for the last rotational rate listed, place test panel RATE TABLE switch in the STOP position.

3. Power Failure Test. (TO para. 16-5)

a. Results of power failure test. Sat_____. Unsat_____.

b. In the spaces below, list any abnormal indications observed.

(1) ____.

(2) ____.

(3) ____.

Caution: Wait five minutes for the switching rate gyro motor to coast down before removing the unit from the rate table. Otherwise component damage may result.

4. Conclusion of Testing.

a. After completion of paragraph 16-6, have the instructor check your workbook.

b. Replace dust caps on equipment as required.

c. Replace components in storage.

SECTION D

BENCH CHECK OF THE DUAL TIMER

EQUIPMENT

	Basis of Issue
AJM-17 Test Set	1/student
Electronic Counter (H-Packard)	1/student
Dual Timer	1/student
TO 5A1-9-2-2	1/student
Workbook	1/student

PROCEDURE

Turn to section 21 in TO 5A1-9-2-2. Follow the procedures step-by-step completing all sections required. Record your results in the spaces provided in this workbook. This workbook will be checked by the instructor. Remove your jewelry.

INSPECTION

a. Preliminary Operation Instructions. (Refer to TO para 21-2.)

In the spaces provided, list any damages found during the visual inspection for para 21-2, steps 1 through 3, then provide necessary responses for the remaining steps.

1. ____

2. ____

3. ____

4. Satisfactory ________ Unsatisfactory ________

5. Satisfactory ________ Unsatisfactory ________

6. Satisfactory ________ Unsatisfactory ________

7. Satisfactory ________ Unsatisfactory ________

1815

Steps 8 through 11

No response required.

b. Initial Timer Warm-Up. Provide the necessary responses for steps 1 through 7 in para 21-3.

1 through 5 - No response required

5 Satisfactory ________ Unsatisfactory ________

6 through 7 - No response required

c. Pullup and Release Timer. Use table 1 below to record Electronic Counter Indications when performing procedures outlined in para 21-4. Check as Satisfactory or Unsatisfactory.

Mode Switch Position	Dual Timer		Electronic Counter Indications (Seconds)	Sat.	Unsat.
	Pullup	Release			
4	30.0	15.0			
4	0.2	0.2			
3	60.0	0.0			
3	30.0	0.0			
3	0.2	0.0			
4	0.0	30.0			
4	0.0	15.0			
4	0.0	0.2			

Table 1.

d. Lighting. Provide the necessary responses for steps 1 and 2 in para 21-5.

1. ON ________ OFF ________

2. Satisfactory ________ Unsatisfactory ________

e. Automatic Shutoff. Provide the necessary responses for steps 1 through 4 in para 21-6.

Steps 1 through 3. No response required.

1816

4. Electronic Counter Indication ________________________.

Satisfactory __________ Unsatisfactory __________

f. Conclusion of testing. (Refer to para 21-7)

1. Complete procedures in para 21-7. No response required.

2. Have your instructor check your workbook.

3. Replace components in storage.

1905

PREPARE THE MAN

PROGRAMMED TEXT 3ABR32531-PT-404
3ABR32632B-PT-402C
3ABR32530-1-PT-209

Technical Training

Automatic Flight Control Systems Specialist
Avionics Instrument Systems Specialist
Integrated Avionics Systems Repairman

MC-1 COMPASS CALIBRATOR

13 May 1974

AIR TRAINING COMMAND

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes PT 3ABR32531-PT-405, 3ABR32632B-PT-406, 3ABR32530-1-PT-903A, 13 April 1973.
OPR: TAS
DISTRIBUTION: X
TAS - 700; TTOC - 4

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR32531 course of instruction, and was validated using 20 students enrolled in that course. Ninety-five percent of the students achieved the objectives as stated. The average time required to complete this text was 1 hour 37 minutes.

OBJECTIVES

After completing this programmed text, and without the aid of reference, demonstrate your knowledge of the MC-1 compass calibrator by:

1. Identifying the purpose of the MC-1 and each of its components with an accuracy of 80%.

2. Matching each MC-1 component to its function with an accuracy of 80%.

3. Identifying the compass swing site requirements with an accuracy of 70%.

INSTRUCTIONS

This programmed text presents information in small steps called frames. Each frame is followed by some form of questioning. Immediately after reading each frame, you will make the required response. Check your answers each time with the correct answer shown at the end of the following frame. If you make the correct response, go on to the next frame. If you make an incorrect response, reread the frame before going on to the next frame. Be sure you understand the material presented in each frame before continuing.

1819

The gyro stabilized magnetic compass system provides aircraft crew members with indications of the aircraft's magnetic heading. Readings taken from the compass indicator provide references for navigating the aircraft. Unless these indications are without error, accurate navigation is not possible. Compass swings are performed to insure magnetic heading accuracy. Compass swings determine the amount of error in the indicator readings and are used to remove these errors. In this text, you will learn the procedures used with the MC-1 compass calibrator. The calibrator is used to determine the amount of error in a compass system and to calibrate the system. The MC-1 is used to calibrate most modern aircraft compass systems that use a remote transmitter as a directional reference.

No Response Required.

1908

1820

Frame 2

When swinging a compass system, using a sight compass or compass rose, the aircraft must be towed or taxied through 360° of azimuth. When using the MC-1 compass calibrator to perform the swing, the aircraft is parked on a north-south line. With the MC-1, the aircraft is not moved during the swing.

Place a check (✓) in front of the true statements.

_____a. Sight compasses are used with the MC-1.

_____b. When using a sight compass, the aircraft is not rotated through 360°.

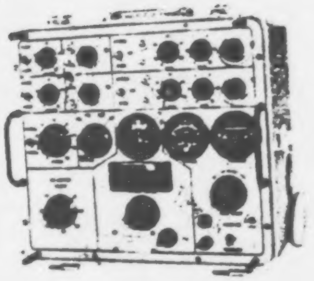
_____c. When using the MC-1, the aircraft remains on a north-south line.

1909

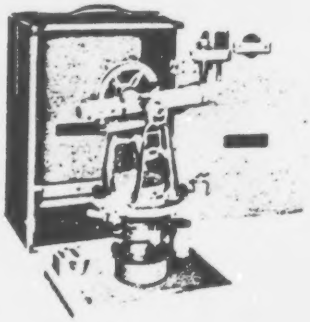
Frame 3

The MC-1 Compass Calibrator consists of the components shown. The description and purpose of these components will be defined in the following frames.

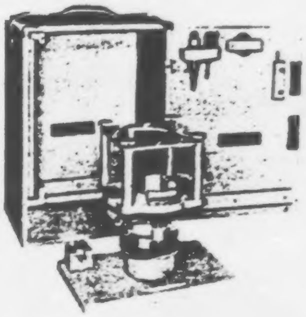
No Response Required



CONSOLE



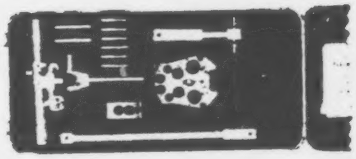
MONITOR



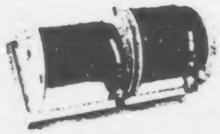
TURNTABLE

POWER SUPPLY

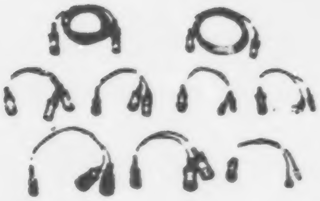
TRIPOD



OPTICAL TRANSFER EQUIPMENT



CABLES



CONNECTORS

MC-1 Components and Auxiliary Equipment.

Answers to Frame 2: ___a. ___b. _✓_c.

1822-

Frame 4

A magnetic survey of the compass swing location must be accomplished. Accurate compass swings cannot be performed until this is done. The purpose of the magnetic survey is to determine whether the earth's magnetic field in that area is uniform in both direction and strength.

Place a check (✓) in front of the true statements below.

_____a. The magnetic survey is to check the accuracy of the aircraft's compass.

_____b. Uniformity of the earth's magnetic field is checked during a magnetic survey.

_____c. Magnetic surveys are performed after compass swings.

1911

A selected area which meets the conditions of the magnetic survey must be checked at least once a year. This check is to see if the earth's magnetic field has changed in the swing area. The check will also be made if there is a physical change in the site (new buildings, roads, etc.). A physical change may result in a magnetic disturbance.

Place a check (✓) in front of the true statements.

_____a. Compass swing areas must be checked at least once a year.

_____b. Checks of the area are made to see if the earth's magnetic field is the same as during the initial survey.

_____c. Checks are not necessary when new buildings are constructed in the swing area.

Answers to Frame 4: _____a. __✓__b. _____c.

1824

Frame 6

The compass swing site must be easy to get to. It must also be large enough to allow the aircraft to be towed in and aligned to magnetic north. The area must be free of outside magnetic disturbances such as large buildings, towers and traffic. If the magnetic survey determines that the earth's magnetic field is not uniform in both strength and direction, then another location must be selected. On page 7 there is an illustration of a typical swing site and equipment set up for performing a compass swing.

Using the illustration when needed, place a check (✓) in front of the true statements.

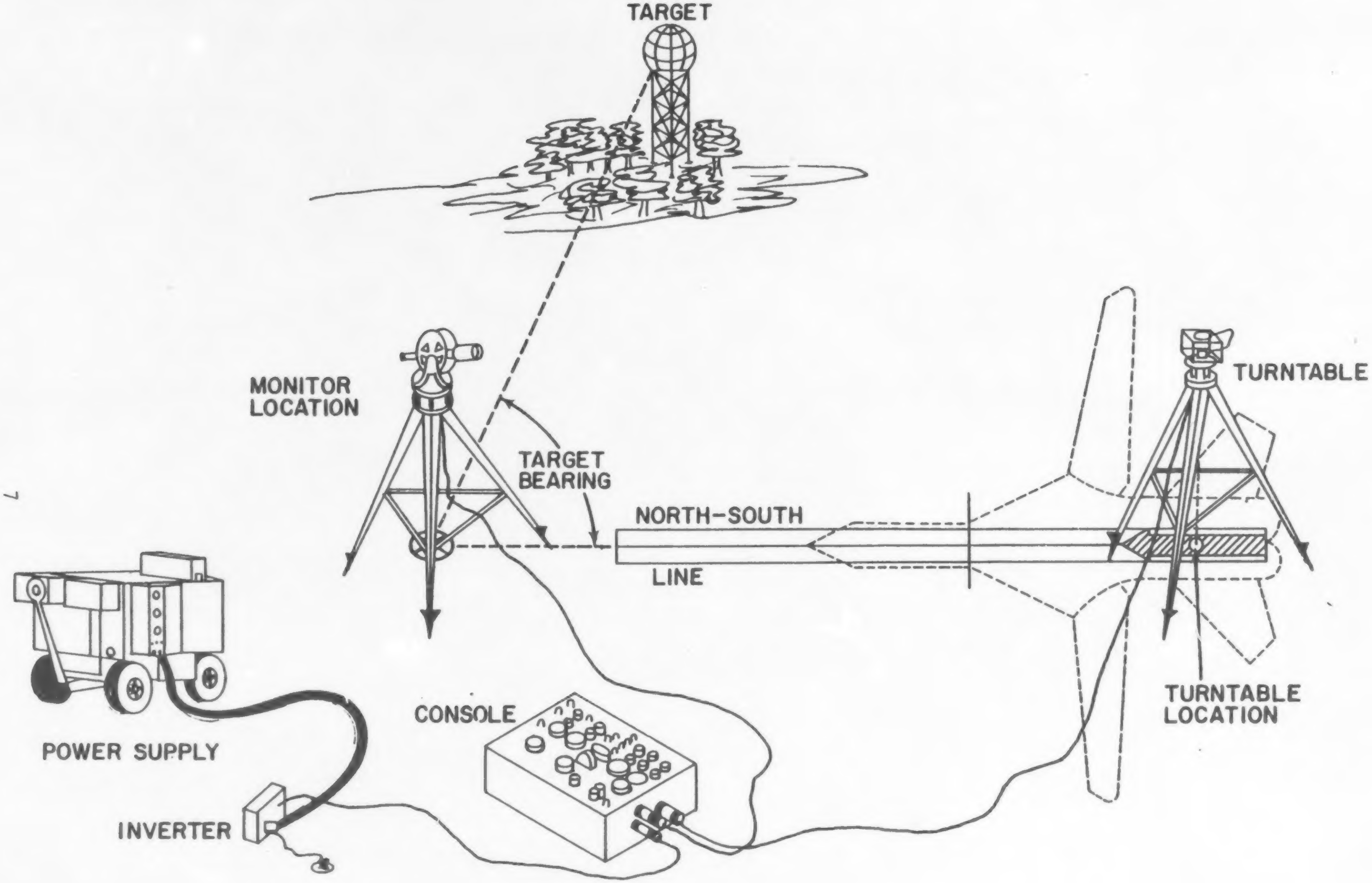
_____a. Area size has no bearing on the swing area selection.

_____b. Another area must be used if the magnetic field is not uniform in strength or direction.

_____c. A metal shed near the swing area would have no effect on the swing area.

Answers to Frame 5: __✓__a. __✓__b. _____c.

1913


TARGET
MONITOR LOCATION
TARGET BEARING
NORTH-SOUTH
LINE
TURNTABLE
TURNTABLE LOCATION
CONSOLE
POWER SUPPLY
INVERTER

Compass Swing Equipment Set-Up.

1925

Frame 7

The components of the MC-1 calibrator used in the area survey are:

1. Field monitor - used with the console during the magnetic survey to measure the strength and direction of the earth's magnetic field.

2. Console - has the necessary controls, switches and indicators to perform surveys and compass swings.

3. Power supply - is an inverter with its own mounting, connecting provisions and power cable. This unit converts DC to AC 400-Hertz for console power.

Place a check (✓) in front of the components listed below that are used to perform a magnetic survey.

_____a. Console.

_____b. Turntable.

_____c. Field monitor.

_____d. Power supply.

Answers to Frame 6: _____a. __✓__b. _____c.

Let's review the material that has been covered so far. Place a check (✓) in front of the true statements below.

_____a. When using the MC-1 to perform compass swings, the aircraft must be rotated through 360°.

_____b. Magnetic surveys are performed to check the output of the aircraft compass.

_____c. Magnetic surveys must be performed before compass swings can be accomplished.

_____d. A check of the swing site must be performed at least once each year.

_____e. Areas to be surveyed must be at least 100 square yards in size.

_____f. When performing compass swings using the MC-1, sight compasses are not used.

Place a check (✓) in front of the components that are used during a magnetic survey.

_____g. Turntable.

_____h. Console.

_____i. Monitor.

_____j. Power supply.

Answers to Frame 7: _✓_a. ____b. _✓_c. _✓_d.

1828

Frame 9

The monitor resembles an engineer's type transit. It consists of:

1. A tripod used for mounting the following:

   a. A 22 power telescope for sighting targets. The telescope contains adjustments for focusing.

   b. An azimuth dial that is provided for alignment of the monitor and reading directions viewed through the telescope.

   c. The sensing unit which senses the direction of the earth's magnetic field (a nonpendulous sensitive element).

Match the items in column A with their function in column B by placing the correct number in the proper space.

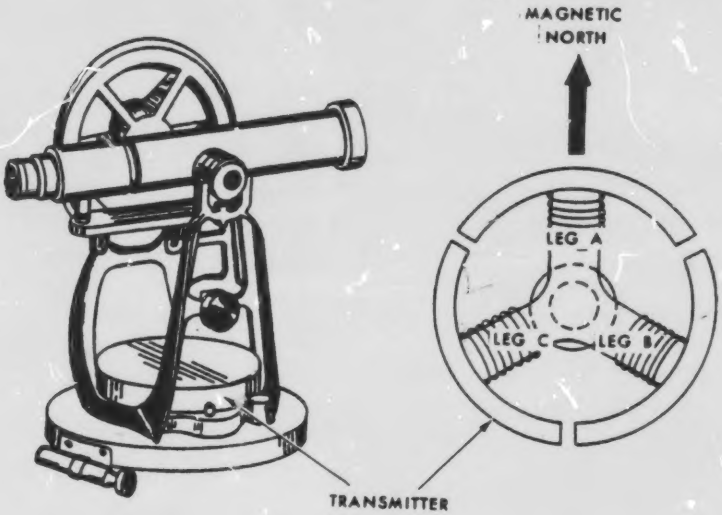
Column A	Column B
_____a. Azimuth dial	1. Provided for alignment of the monitor and reading directions viewed through the telescope.
_____b. Sensing unit	2. Focusing for distance and cross hair.
_____c. Adjustments	3. Mounting for the monitor.
	4. Senses the earth's magnetic field.

Answers to Frame 8: ____a. ____b. ✓ c. ✓ d. ____e.

✓ f. ____g. ✓ h. ✓ i. ✓ j.

1913

The master direction sensing unit is mounted below the telescope as shown in the figure below. Like the remote compass transmitter, this unit contains three pickup coils. These coils sense the north-south direction of the earth's magnetic field. Unlike the compass transmitter, the pickup coils are not pendulously (hanging) mounted. This means that much care must be taken to insure that the monitor is level when it is being used.



Place a check (✓) in front of the true statements below.

_____a. The pickup coils in the sensing unit sense the direction of the earth's magnetic field.

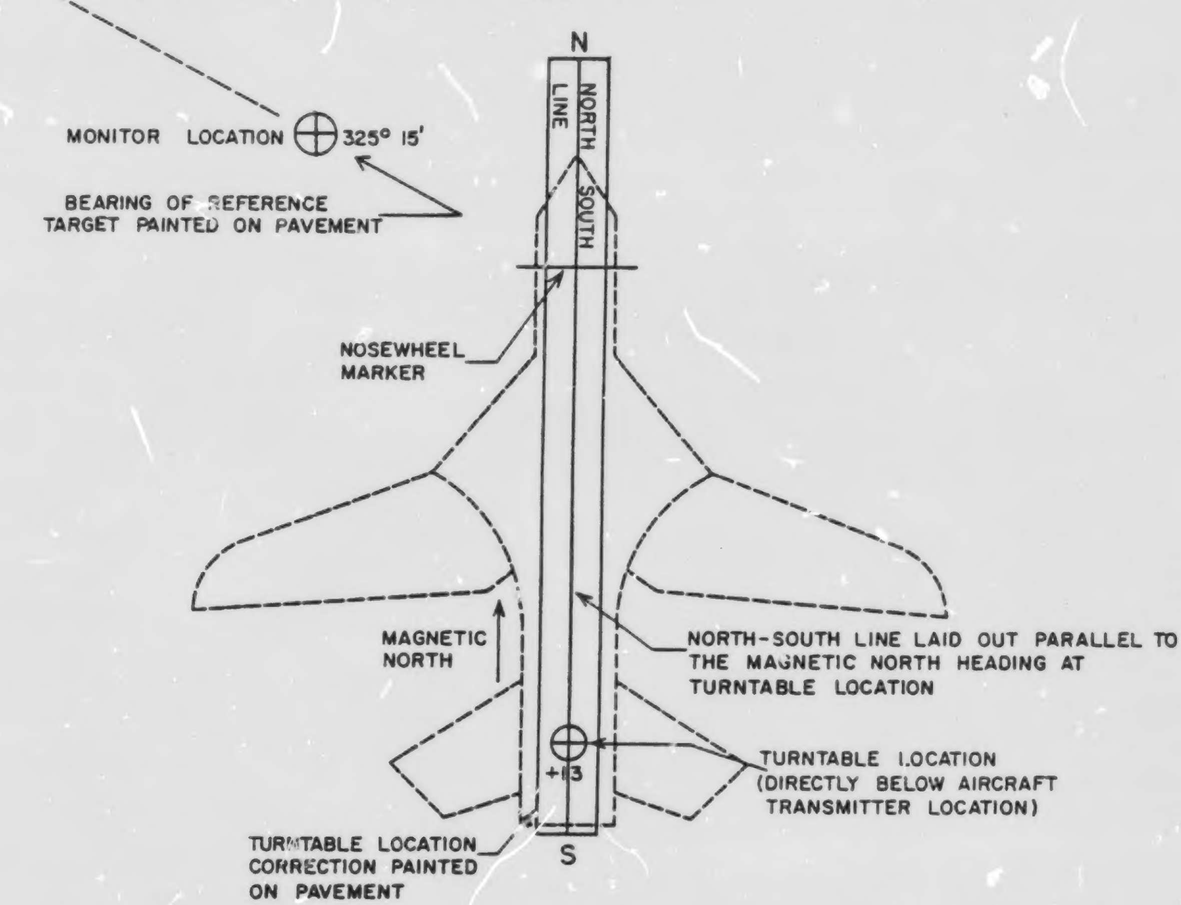
_____b. The sensing unit is pendulously mounted.

_____c. Care must be taken in leveling the monitor.

Answers to Frame 9: __1__ a. __4__ b. __2__ c.

Frame 11

The console and monitor are used to determine the bearing of a reference target. They also determine the permanent location of components used to perform the swing and to establish a permanent North-South line as shown below. This line is used to align the aircraft to magnetic north during compass swings as shown in the figure. The location picked for the field monitor, turntable, and North-South line are determined during survey of the swing site. The target bearing is permanently recorded near the location established for the monitor. Note that the bearing in the figure is 325° 15' and would be marked on the pavement, the turntable location is also shown in the figure.


N
NORTH
LINE
SOUTH
MONITOR LOCATION
325° 15'
BEARING OF REFERENCE TARGET PAINTED ON PAVEMENT
NOSEWHEEL MARKER
MAGNETIC NORTH
NORTH-SOUTH LINE LAID OUT PARALLEL TO THE MAGNETIC NORTH HEADING AT TURNTABLE LOCATION
+13
TURNTABLE LOCATION (DIRECTLY BELOW AIRCRAFT TRANSMITTER LOCATION)
TURNTABLE LOCATION CORRECTION PAINTED ON PAVEMENT
S

Using the illustration when needed, place a check (✓) in the space next to the true statements.

_____a. The reference target bearing, location of components and the north-south line are determined by using the console and the turntable.

_____b. The target bearing will be marked near the north-south reference line.

_____c. The console and monitor are used during the survey to determine component location.

_____d. The turntable correction is +13°.

Answers to Frame 10: __✓__a. _____b. __✓__c.

1831

During the initial area survey, the reference target and the reference target bearing are established. The target should be an object (building or tower) 1/2 mile or more from the swing site (see figure on page 7, Compass Swing Equipment Set-Up). The magnetic bearing of this target is used as a reference during compass swings. The bearing of this target is permanently marked at the selected monitor location.

Place a check (✓) in front of the true statement(s).

_____a. Reference targets are less than 1/2 mile from the swing location.

_____b. The bearing of the reference target is permanently marked at the monitor location.

_____c. Target bearing is used during compass swings.

Answers to Frame 11: _____a. _____b. __✓__c. __✓__d.

1921

1832

Frame 13

Place the number from Column II in the space provided in Column I, to match the purpose to the unit.

I

_____a. Adjustments

_____b. Azimuth Dial

_____c. Sensing unit

II

1. Focusing for distance and cross hairs.
2. Mounting for the monitor.
3. Reads direction received through the telescope.
4. Senses the earth's magnetic field.

Complete the following statements by underlining the correct answer(s).

d. The target bearing will be permanently marked near the (turntable, monitor) location.

e. The (monitor and console, turntable and console) are used to determine the reference target bearing.

f. Reference targets must be at least (1/4, 1/2, 3/4) mile from the swing site.

Answers to Frame 12: _____a. __✓__b. __✓__c.

1922

Compass swings can be performed after the magnetic survey has been completed. The MC-1 components that are used to complete a magnetic survey are also used to perform the compass swings. In addition to the console, monitor, and power supply, the turntable is also used to perform the compass swing.

Place a check (√) in front of the true statements below.

____a. Compass swings are performed after area magnetic surveys are completed.

____b. Components used during the survey are also used during compass swings.

____c. The turntable is the MC-1 component not used during the survey.

Answers to Frame 13:

1 a. 3 b. 4 c. Monitor d. Monitor and Console e. 1/2 f.

Frame 15

A compass swing data sheet (AFTO Form 53) is provided for use when compass swings are performed. This sheet is used as a guide for performing compass swings. It gives control and switch settings to be set on the console for each check. Spaces are provided for recording values read from the monitor and console for each step. The entries in the spaces are keyed to the paragraph in the TO that is used to perform the operating procedures.

Place a check (✓) next to the true statement(s).

_____a. The AFTO Form 53 provides procedures to perform a compass swing.

_____b. A swing data sheet is a guide to be used when performing compass swings.

_____c. Spaces are provided on the swing sheet to record aircraft compass readings.

_____d. The AFTO Form 53 is keyed by paragraph to the TO.

Answers to Frame 14: _✓_ a. _✓_ b. _✓_ c.

Place a check (✓) in front of the components listed below that are used during compass swings.

_____a. Monitor.

_____b. Console.

_____c. Power Supply.

_____d. Turntable.

Complete the statements below by underlining the correct answer(s).

e. Compass swing are performed (before, after) the magnetic survey is accomplished.

f. The Swing Data Sheet (is, is not) used as a guide in performing compass swings.

Answers to Frame 15: _____a. __✓__b. _____c. __✓__d.

Frame 17

The compass swing procedures consist of the following related operations that must be performed in the order given:

a. Equipment Set-up

b. Magnetic North Alignment of the Transmitter

c. Determination of the E1 and E2 Voltages or the Transmitter.

d. Determination of the 180 and 270 Crosstalk Values.

e. Optical Transfer of the Transmitter.

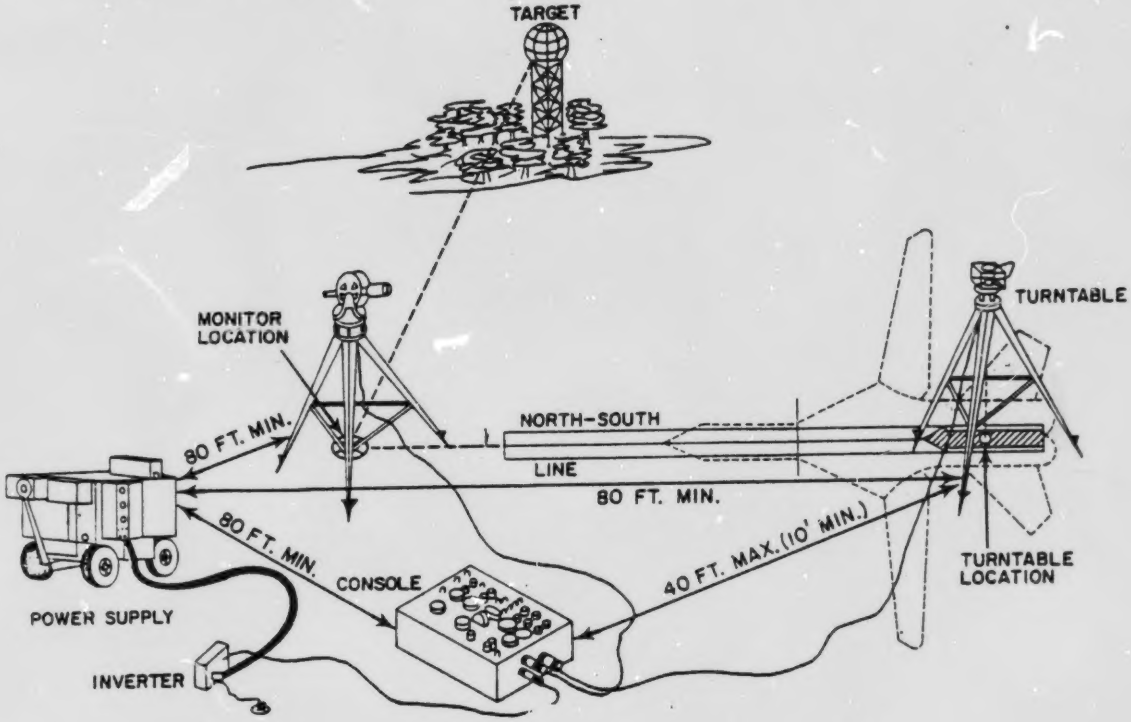
f. Actual Aircraft Compass Swing.

Each of the above steps will be covered separately. These steps will include procedures to be followed to perform each major operation. You will find that the first five steps are preparations necessary in performing the actual aircraft compass swing. The last step (f) is the actual compass swing.

NO RESPONSE REQUIRED

Answers to Frame 16: _✓_ a. _✓_ b. _✓_ c. _✓_ d. _After_ e. _is_ f.

The first step you must perform is the equipment set-up. The field monitor and turntable are set up at the locations established during the magnetic survey. Cable connections are made between the power supply, monitor, and console, as shown below. Note that certain distances have to be met in setting up the equipment to prevent electrical interferences. The aircraft is not normally in position at the swing area at this time.


TARGET
MONITOR LOCATION
TURNTABLE
NORTH-SOUTH
LINE
80 FT. MIN.
80 FT. MIN.
80 FT. MIN.
40 FT. MAX. (10' MIN.)
TURNTABLE LOCATION
CONSOLE
POWER SUPPLY
INVERTER

Compass Swing Equipment Setup.

Place a check (✓) in front of the true statement(s).

_____a. When setting up for a compass swing, calibrator components can be placed wherever it is convenient to use them.

_____b. The aircraft must be in position before calibrator components are set into position.

_____c. The field monitor and turntable locations are selected during the area survey.

1838

Frame 19

After the monitor has been set up and leveled at its proper location, it is used to determine the magnetic bearing of the North-South line. This is to determine whether the earth's magnetic field has changed in direction and strength since the original area survey was performed. Any difference that exists is known as a monitor index error.

The monitor will be used to "monitor" any changes in magnetic conditions during the remainder of the compass swing procedures.

Place a check (✓) in front of the true statement(s).

_____a. During set up procedures, the initial survey of the swing area is made.

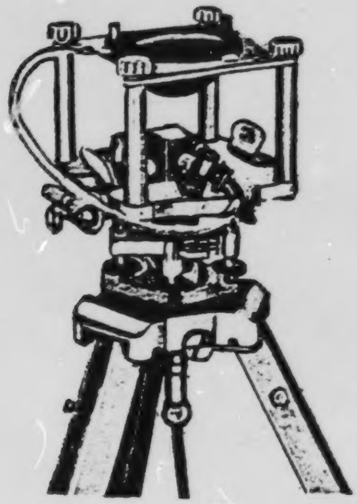
_____b. The monitor is used to determine the magnetic bearing of the North-South line.

Answers to Frame 18: ___a. ___b. _✓_c.

1928

Frame 20

The second step is the magnetic north alignment of the aircraft remote compass transmitter. The compass transmitter must be removed from the aircraft and mounted on the turntable. The turntable is similar to the monitor. In place of the telescope and master sensing unit, it has a mounting flange for the transmitter. The dial on the turntable serves as the azimuth reference for positioning the transmitter to the desired headings. See the figure below.



Transmitter Mounted on Turntable.

Check the true statements below.

_____a. In this portion of the swing, the monitor transmitter is aligned to north.

_____b. A master sensing unit is provided on the turntable.

_____c. During north alignment of the transmitter, it remains in the aircraft.

_____d. To align the transmitter, it is mounted on the turntable.

_____e. A telescope is provided on the turntable to align the transmitter to the desired heading.

Answers to Frame 19: ___a. _✓_b.

1840

Frame 21

Recall that the function of the remote compass transmitter is to supply the compass system with an electrical signal which represents the direction the aircraft is flying. This signal is produced by the earth's magnetic field and is processed in the system to control the position of a gyro or it is applied to an indicator. As the aircraft changes its direction, the transmitter turns with it. This causes a change in the output voltage of the three pickup coils which produce the signal.

NO RESPONSE REQUIRED

Answers to Frame 20: ____a. ____b. ____c. _✓_d. ____e.

1930

After the transmitter has been aligned to magnetic North the next step is to determine its electrical characteristics. Specifically, the value of the voltages required to create magnetic fields within the transmitter to cancel the earth's existing field. These voltages are referred to as E1 and E2 voltage. Both the E1 and E2 voltages are determined from the average of readings taken with the transmitter initially set to a specific direction and then with the transmitter rotated 180 degrees. For example; E1 voltage is determined by taking three readings with the transmitter set at 180° and three readings with the transmitter at 0°. The average of the six readings is the E1 voltage. E2 voltage is determined by taking three readings with the transmitter set at 270° and three readings with the transmitter at 90°. The average of the six readings is the E2 voltage.

The E1 and E2 voltages will then be used later to perform an Electrical Compass Swing. (Electrically rotating the magnetic field relative to the transmitter).

Check (✓) the true statements below.

_____a. E1 and E2 voltages are detrmined by setting the monitor at 0° and 180°.

_____b. E2 voltage is determined by setting the turntable at 270° and 90°.

_____c. An average of the six readings is used to determine the E1 voltage.

1842.

Frame 23

Match the components and component units in Column A to their function in Column B.

Column A

_____1. Monitor

_____2. Monitor telescope

_____3. Monitor sensing unit

_____4. Turntable

_____5. Turntable azimuth dial

_____6. Power supply

_____7. Console

Column B

a. Contains controls, switches, and indicators necessary for performing swings and magnetic surveys.

b. Used with the console to measure the direction and strength of the earth's magnetic field.

c. Provides component power and connections between calibrator components.

d. Is not pendulously mounted and senses the north-south direction of the earth's magnetic field.

e. Used for sighting a target at least 1/2 mile away.

f. Provides a mounting for the aircraft remote compass transmitter.

g. Used for aligning the aircraft on the north-south line.

h. Provides a reference for reading the direction to which the remote compass transmitter is pointing.

Complete the following statements by underlining the correct answers.

8. The monitor is used to "monitor" conditions of the earth's magnetic field .... (remote compass transmitter) during the compass swing.

9. The remote compass transmitter is mounted on the (monitor...... turntable........console).

10. An (azimuth dial....master sensing unit) is provided on the turntable to align the transmitter to the desired headings.

11. The electrical characteristics of each (console....master sensing unit....remote compass transmitter) determine the E1 and E2 voltage requirement for the electrical swing.

12. When determining the E1 and E2 voltages, readings are taken at (every 15 degrees heading....the cardinal headings).

Answers to Frame 22: _____a. __✓__b. __✓__c.

1932

The remote compass transmitter output signals contain errors which are produced by the unit itself. These errors are due to the difference in construction of the pickup coils and by the magnetic field from one coil affecting the output of the other two coils. This is known as Crosstalk Error and must be compensated for to achieve a precise electrical swing.

Place a check (√) in front of the true statement(s).

_____a. Errors in the transmitter output are due to construction of the unit and the magnetic field in each pickup coil.

_____b. Transmitter errors are determined during the mechanical portion of the swing.

_____c. Compass transmitter errors are produced by the earth's magnetic field.

Answers to Frame 23:

b 1.   e 2.   d 3.   f 4.   h 5.   c 6.   a 7.

earth's magnetic field 8.   turntable 9.   azimuth dial 10.

remote compass transmitter 11.   the cardinal headings 12.

Frame 25

The procedures followed up to this point are performed to determine the serviceability of the compass transmitter. Equipment has been set up at its proper location; checks have been made to determine that the outputs ary within a specific tolerance. The area has been resurveyed, the transmitter mounted and aligned to north. Transmitter output and amount of output error have been checked. If the compass transmitter is not serviceable, a new transmitter must be obtained. In this case the swing procedure must be started over. If the transmitter is serviceable, the procedure will be continued.

Place a check (✓) in front of the true statement(s).

_____a. Up to this point in the swing, it should be determined whether or not the transmitter output is within tolerance and the transmitter can be used.

_____b. At this point, if the transmitter is not serviceable, the swing will continue without one.

_____c. If the transmitter is serviceable, the swing procedures will be continued.

Answers to Frame 24: __✓__a. _____b. _____c.

The remainder of the swing will be performed with the remote compass transmitter in the aircraft. The optical transfer is the next step of the compass swing procedure. The transmitter must be moved from the turntable back to the aircraft. When the transmitter is returned, it must be aligned to the aircraft's longitudinal axis.

Place a check (✓) in front of the true statements(s).

_____a. The process of moving the monitor to the aircraft is called Optical Transfer.

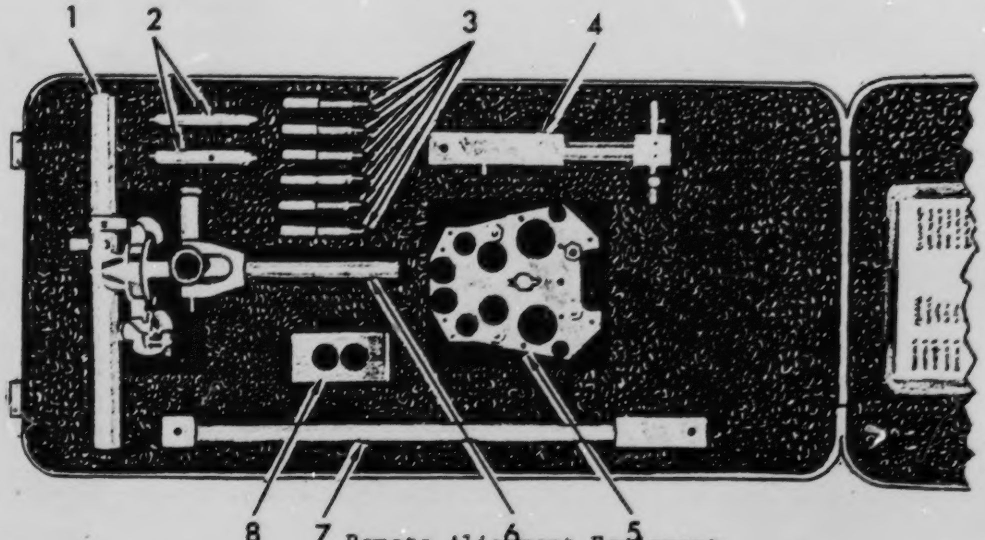
_____b. When the transmitter is mounted on the aircraft, it must be aligned with the longitudinal aircraft axis.

Answers to Frame 25: __✓__a. _____b. __✓__c.

1846

Frame 27

To complete an optical transfer optical alignment equipment must be used. This equipment is used when moving the transmitter from the turntable to the aircraft. Optical transfer equipment consists of a telescope which is attached to the transmitter while it is in place on the turntable. The figure below, and legend, shows the placement of the optical alignment equipment with telescope and necessary subassemblies and shafts. An azimuth adjustment makes it possible to rotate the telescope in respect to the transmitter.



Remote Alignment Equipment.

1. Telescope
2. Leg Alignment Subassembly
3. Transmitter Mounting Studs
4. B-52D Adapter Subassembly
5. Support Plate Subassembly
6. Short Coupling Shaft
7. Long Coupling Shaft
8. Leg Adjusting Subassembly

Place a check (✓) in front of the true statement(s).

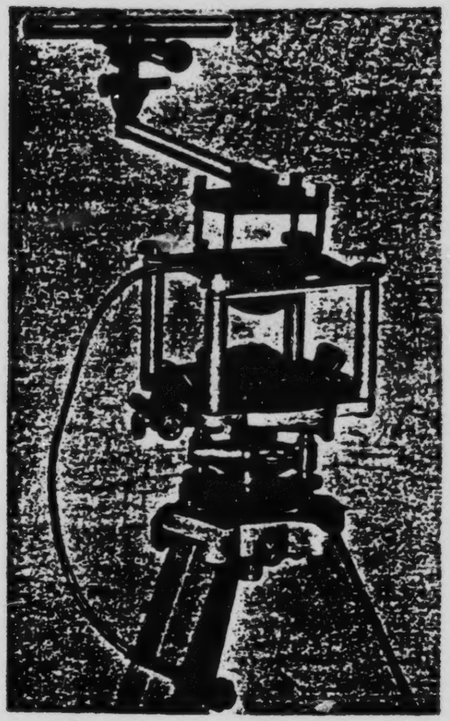
____a. When transferring the transmitter, optical alignment equipment must be used.

____b. Optical alignment equipment consists of a master transmitter and subassemblies.

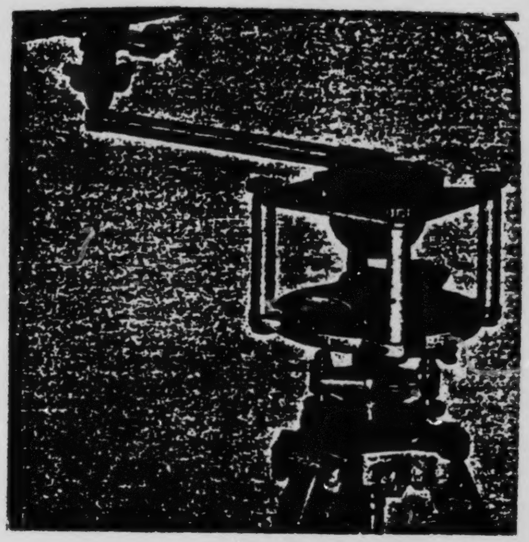
Answers to Frame 26: ____a. ✓ b.

1936

Before the aircraft is towed into position, the optical transfer equipment must be mounted on the remote compass transmitter. This is accomplished using the mountings and fixtures provided for the type of aircraft being swung. Special mountings and fixtures are also provided for the type of transmitter used in that particular aircraft. See the figure below and on the opposite page.



Stabilizer - Mounted
Thin Transmitter.



Stabilizer - Mounted
Standard Transmitter.

Place a check (✓) in front of the true statement(s).

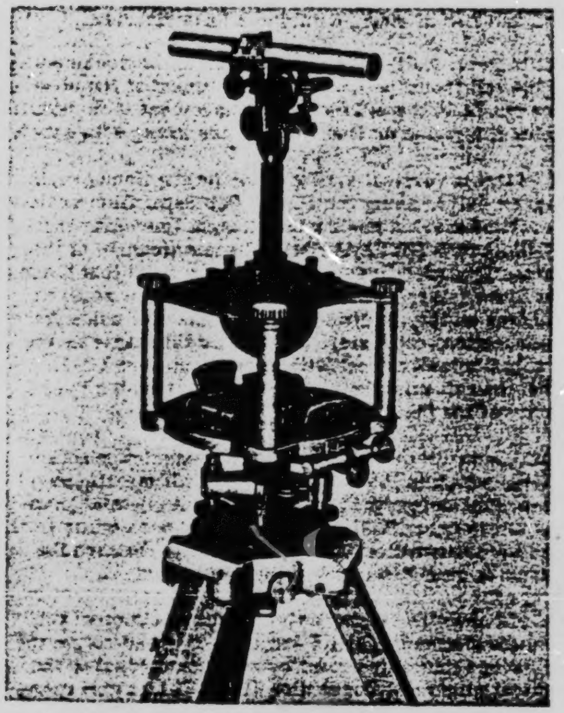
_____a. Optical alignment equipment is mounted on the transmitter before the aircraft is in place.

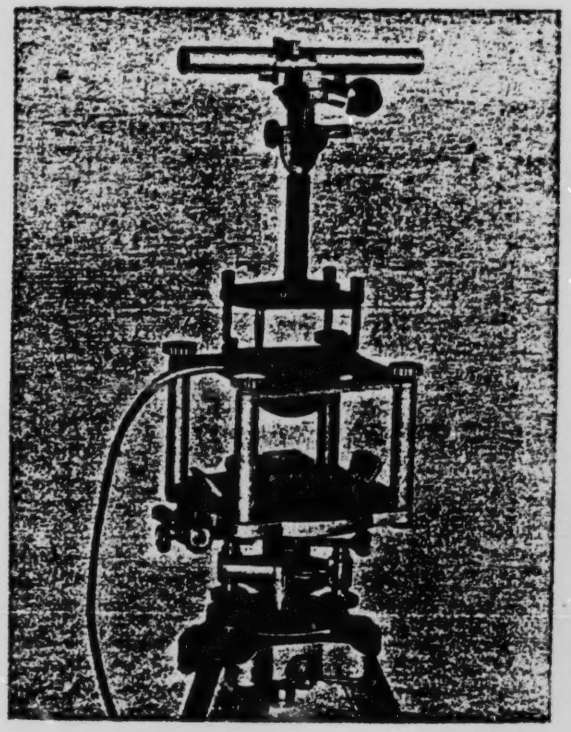
_____b. Special mountings and fixtures are provided for a particular type of aircraft and/or transmitter.

Answers to Frame 27: _✓_a. ____b.

Frame 29

With the telescope mounted on the transmitter, a target will be sighted through the telescope. The target (any target) must be at least one-half mile away. It must be in view from both the turntable location and transmitter location in the aircraft. The telescope will be aligned with its cross hairs on the target. When the cross hairs are on the target, the telescope will be locked into place on the transmitter. When the transmitter is replaced in the aircraft, sighting back on the target will insure that the transmitter is aligned correctly in the aircraft.





Place a check (✓) in front of the true statement(s).

_____a. The target used as a reference for aligning the transmitter in the aircraft must be at least 1/4 of a mile away.

_____b. The target must be visual to both the turntable location and transmitter locations.

_____c. Using the telescope and target insures that the transmitter is aligned correctly in the aircraft.

Answers to Frame 28: __✓__a. __✓__b.

Frame 30

After the reference target (for transfer) has been sighted, the aircraft will be towed into the swing area. When the aircraft is towed into the swing area, it is aligned on the north-south line. There is usually some misalignment between the aircraft and the north-south line. The amount of misalignment must be determined. The difference between the north-south line and the aircraft's longitudinal axis must be set into the transfer equipment. This is done to insure accurate alignment of the transmitter in the aircraft.

Place a check (✓) in front of the true statement(s).

_____a. The aircraft is towed into the swing area after alignment equipment is mounted and the target is sighted.

_____b. Perfect alignment on the north-south line is seldom possible.

_____c. Knowing the amount of misalignment between the aircraft and the north-south line is not necessary for aligning the transmitter in the aircraft.

Answers to Frame 29: _____a. __✓__b. __✓__c.

Frame 31

Upon completion of the optical transfer of the transmitter from the turntable to the aircraft, an electrical swing at the four cardinal headings is performed. The transmitter is then indexed and the N-S and E-W compensation adjustment is made. This procedure is called Index and One-Cycle Error Compensation.

Place a check (✓) in front of the true statement(s).

_____a. Before the transmitter can be returned to the aircraft, the amount of error in the monitor signal must be determined.

_____b. Misalignment between the north-south line and the aircraft longitudinal axis must be compensated for.

_____c. Optical transfer equipment is used to remove the transmitter from the aircraft.

_____d. The monitor telescope is used during the transfer procedures.

_____e. After the optical alignment equipment is mounted on the transmitter, the aircraft is towed into position.

_____f. To insure that the transmitter is aligned correctly in the aircraft, a target at least 1/2 a mile away from the swing area must be sighted through the alignment telescope.

Answers to Frame 30: __✓__a. __✓__b. _____c.

When the N-S and E-W errors have been reduced to a minimum, further compensation will depend upon the aircraft compass system compensation available. For example, if the compass system used a 24 point compensator, the HDG SELECTOR on the control console can be rotated to headings spaced 15° apart and the appropriate potentiometer adjusted to remove any remaining error.

Place a check (✓) in front of the true statement(s).

_____a. After the index and one-cycle compensation is completed, no further calibration can be made.

_____b. If a 24 point compensator is used, readings are taken at every 15 degrees.

Answers to Frame 31: _____a. __✓__b. _____c. _____d. __✓__e. __✓__f.

1941

1852.

Frame 33

When performing the steps of the compass swing, various values are recorded on the swing data sheet (AFTO Form 53). These values represent some of the following:

1. Reference target bearing.
2. Monitor values at cardinal headings.
3. Remote compass transmitter outputs.
4. Compass transmitter errors.

These values are used to perform calculations of formulas provided on the swing data sheet. This provides the necessary data for setting the controls on the console. These settings produce console outputs needed during the remainder of the swing.

Place a check (✓) in front of the true statement(s).

_____a. The AFTO Form 53 provides formulas for calculations used during various parts of the swing.

_____b. Calculations provide data for operating the console during the swing.

_____c. Console outputs are not used during the latter part of the swing.

Answers to Frame 32: _____a. __✓__b.

1942

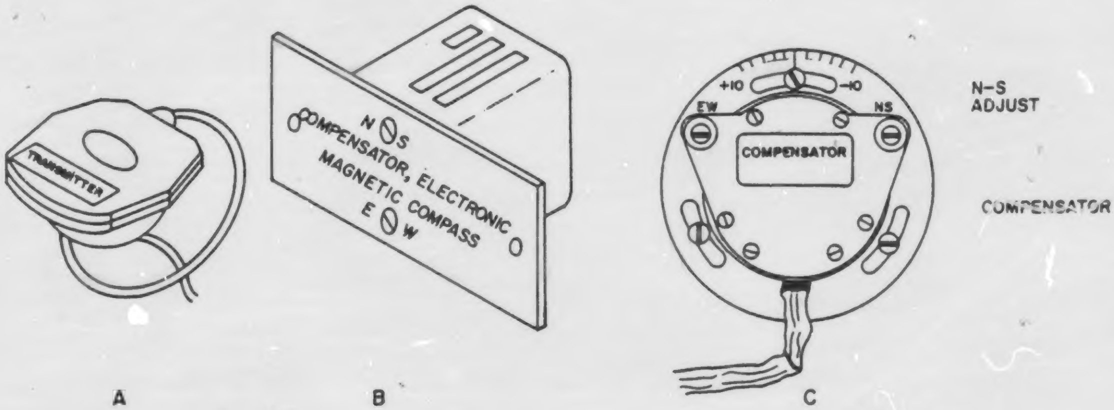
It was stated earlier in the text that when using the MC-1 calibrator, the compass swing can be performed without rotating the aircraft. This is done by using the information recorded on the swing data sheet (AFTO Form 53). These recordings provide values to be set into the console. The settings will produce current outputs which are transmitted to the aircraft's compass system. During this phase of the swing (the actual compass swing), all heading signals from the remote compass transmitter are produced by outputs from the console.

NO RESPONSE REQUIRED

Answers to Frame 33: _✓_ a. _✓_ b. ____ c.

Frame 35

The console outputs are precisely controlled DC currents. The currents are passed to the remote compass transmitter, figure A, and through the remote compass transmitter compensator, shown in figure B. Another type of transmitter and compensator is shown in figure C. The compensator in figure C is not electrically connected to the console. You will adjust the N-S, E-W screws when swinging. With the proper values set into the console, its outputs simulate the earth's magnetic field at any desired heading.


TRANSMITTER
N S
COMPENSATOR, ELECTRONIC
MAGNETIC COMPASS
E W
+10
-10
EW
NS
COMPENSATOR
N-S ADJUST
COMPENSATOR
A
B
C

Compass Transmitter and Compensators.

Place a check (✓) in front of the true statement(s).

_____a. Console outputs are precisely controlled AC outputs.

_____b. Console outputs are transmitted first to the remote compass transmitter compensator, and then to the remote compass transmitter.

_____c. Console outputs are transmitted directly to the remote compass transmitter.

_____d. Console outputs simulate the earth's magnetic field.

Frame 36

The console outputs make the compass system react as if the aircraft was actually being turned. The aircraft remains on the north-south line and the earth's magnetic field is simulated. For example, with the proper values set into the console to simulate the earth's magnetic fields at a 90 degree heading, the indicator should indicate 90 degrees, even though the aircraft is still pointing north. By simulating the earth's magnetic field, the compass system errors can be determined and corrected without moving the aircraft.

Place a check (✓) in front of the true statement(s).

_____a. Console outputs affect the compass as if the aircraft were actually turning.

_____b. By simulating the earth's magnetic field, the console outputs can be corrected.

Answers to Frame 35: _____a. __✓__b. _____c. __✓__d.

Frame 37

The console headings simulate the earth's magnetic field at the 4 cardinal headings (N, E, S, W). Compass indicator readings are taken at each cardinal heading. The difference between the simulated cardinal headings and the indicator readings is deviation. The error at each heading is recorded o the swing correction form. Formulas are provided on the AFTO Form 53 to determine the amount of correction to be set into the compass system. Indicator errors are corrected at the remote compass transmitter compensator.

Place a check (✓) in front of the true statement(s).

_____a. The earth's magnetic field is simulated by the turntable.

_____b. Variation is the difference between the simulated heading and the indicator reading.

_____c. Corrections are made on the remote compass transmitter compensator.

Answers to Frame 36: __✓__a. _____b.

1857

The remote compass transmitter compensator contains two adjustment screws shown in figures B and C, Frame 35, Compass Transmitter and Compensators. These screws compensate for deviation error. The compensator supplies DC currents to the remote compass transmitter. These currents are controlled by the N-S and E-W screws. DC currents tend to cancel disturbing magnetic fields which are generated by the aircraft's equipment (single-cycle error).

Place a check (✓) in front of the true statement(s).

_____a. The adjustment screws on the compass transmitter compensator are comparable to the adjustment magnets on the magnetic standby compass.

_____b. Adjustments made at the compensator tend to cancel out the indicator readings.

_____c. Adjustments made on the N-S and E-W screws, compensate for single-cycle error.

Answers to Frame 37: _____a. _____b. __✓__c.

1947

Frame 39

Some aircraft compass systems are provided with a 24 point compensator. The indicator readings are reduced to minimum with the transmitter compensator adjustment screws. Additional corrections can be made on the 24 point compensators. The 24 point compensator provides for "system error compensation." This is error produced by the compass system itself (mechanical errors in the components). Adjustments are made at every 15 degrees of magnetic heading (these are simulated headings using the MC-1).

Place a check (✓) in front of the true statement(s).

_____a. Mechanical errors are corrected at the N-S and E-W screws on the compensator.

_____b. Adjustments on the 24 point compensator are made at every 15 degrees.

_____c. During the swing portion, the aircraft is rotated 360 degrees.

Answers to Frame 38: __✓__a. _____b. __✓__c.

Upon completion of this programmed text you should have a basic knowledge of why the MC-1 compass calibrator is used in place of the sight compass method for performing compass swings. If you did not understand all portions of this text, go back and reread the pertinent frames. When you are confident that you understand the steps and procedures in performing a compass swing, ask your instructor for the appraisal over the material covered in this programmed text.

Answers to Frame 39: _____a. __✓__b. _____c.

Response Sheet 3ABR32531-PT-404
Page 1 of 2

MC-1 COMPASS CALIBRATOR

Frame 1

No Response

Frame 2

____ a.

____ b.

____ c.

Frame 3

No Response

Frame 4

____ a.

____ b.

____ c.

Frame 5

____ a.

____ b.

____ c.

Frame 6

____ a.

____ b.

____ c.

Frame 7

____ a.

____ b.

____ c.

____ d.

Frame 8

____ a.

____ b.

____ c.

____ d.

____ e.

____ f.

____ g.

____ h.

____ i.

____ j.

Frame 9

____ a.

____ b.

____ c.

Frame 10

____ a.

____ b.

____ c.

Frame 11

____ a.

____ b.

____ c.

____ d.

Frame 12

____ a.

____ b.

____ c.

Frame 13

____ a.

____ b.

____ c.

d. (Turntable, Monitor)

e. (Monitor and Console, Turntable and Console)

f. (¼, ½, 3/4)

Frame 14

____ a.

____ b.

____ c.

Frame 15

____ a.

____ b.

____ c.

____ d.

Frame 16

____ a.

____ b.

____ c.

____ d.

e. (before, after)

f. (is, is not)

Frame 17

No Response

Frame 18

____ a.

____ b.

____ c.

Frame 19

____ a.

____ b.

Frame 20

____ a.

____ b.

____ c.

____ d.

____ e.

Frame 21

No Response

Frame 22

____ a.

____ b.

____ c.

Frame 23

____ 1.

____ 2.

____ 3.

____ 4.

____ 5.

Frame 23 cont on next page

1861.

Frame 23 cont

____ 6.

____ 7.

8. (Magnetic field...
remote compass
transmitter)

9. (Monitor...turntable
...console)

10. (azimuth dial...
master sensing unit)

11. (Console...master sensing
unit...remote compass
transmitter)

12. (every 15 degree heading
...the cardinal headings)

Frame 24

____ a.

____ b.

____ c.

Frame 25

____ a.

____ b.

____ c.

Frame 26

____ a.

____ b.

Frame 27

____ a.

____ b.

Frame 28

____ a.

____ b.

Frame 29

____ a.

____ b.

____ c.

Frame 30

____ a.

____ b.

____ c.

Frame 31

____ a.

____ b.

____ c.

____ d.

____ e.

____ f.

Frame 32

____ a.

____ b.

Frame 33

____ a.

____ b.

____ c.

Frame 34

No Response

Frame 35

____ a.

____ b.

____ c.

____ d.

Frame 36

____ a.

____ b.

Frame 37

____ a.

____ b.

____ c.

Frame 38

____ a.

____ b.

____ c.

Frame 39

____ a.

____ b.

____ c.

Frame 40

No Response

MC-1 COMPASS CALIBRATOR

Frame 1

No Response

Frame 2

____ a.
____ b.
____ c.

Frame 3

No Response

Frame 4

____ a.
____ b.
____ c.

Frame 5

____ a.
____ b.
____ c.

Frame 6

____ a.
____ b.
____ c.

Frame 7

____ a.
____ b.
____ c.
____ d.

Frame 8

____ a.
____ b.
____ c.
____ d.
____ e.
____ f.
____ g.
____ h.
____ i.
____ j.

Frame 9

____ a.
____ b.
____ c.

Frame 10

____ a.
____ b.
____ c.

Frame 11

____ a.
____ b.
____ c.
____ d.

Frame 12

____ a.
____ b.
____ c.

Frame 13

____ a.
____ b.
____ c.
d. (Turntable, Monitor)
e. (Monitor and Console, Turntable and Console)
f. (¼, ½, 3/4)

Frame 14

____ a.
____ b.
____ c.

Frame 15

____ a.
____ b.
____ c.
____ d.

Frame 16

____ a.
____ b.
____ c.
____ d.
e. (before, after)
f. (is, is not)

Frame 17

No Response

Frame 18

____ a.
____ b.
____ c.

Frame 19

____ a.
____ b.

Frame 20

____ a.
____ b.
____ c.
____ d.
____ e.

Frame 21

No Response

Frame 22

____ a.
____ b.
____ c.

Frame 23

____ 1.
____ 2.
____ 3.
____ 4.
____ 5.

Frame 23 cont on next page

Frame 23 cont

____ 6.

____ 7.

8. (Magnetic field...
remote compass
transmitter)

9. (Monitor...turntable
...console)

10. (azimuth dial...
master sensing unit)

11. (Console...master sensing
unit...remote compass
transmitter)

12. (every 15 degree heading
...the cardinal headings)

Frame 24

____ a.

____ b.

____ c.

Frame 25

____ a.

____ b.

____ c.

Frame 26

____ a.

____ b.

Frame 27

____ a.

____ b.

Frame 28

____ a.

____ b.

Frame 29

____ a.

____ b.

____ c.

Frame 30

____ a.

____ b.

____ c.

Frame 31

____ a.

____ b.

____ c.

____ d.

____ e.

____ f.

Frame 32

____ a.

____ b.

Frame 33

____ a.

____ b.

____ c.

Frame 34

No Response

Frame 35

____ a.

____ b.

____ c.

____ d.

Frame 36

____ a.

____ b.

Frame 37

____ a.

____ b.

____ c.

Frame 38

____ a.

____ b.

____ c.

Frame 39

____ a.

____ b.

____ c.

Frame 40

No Response

1864

Response Sheet 3ABR32531-PT-404
Page 1 of 2

MC-1 COMPASS CALIBRATOR

Frame 1
No Response

Frame 2
____ a.
____ b.
____ c.

Frame 3
No Response

Frame 4
____ a.
____ b.
____ c.

Frame 5
____ a.
____ b.
____ c.

Frame 6
____ a.
____ b.
____ c.

Frame 7
____ a.
____ b.
____ c.
____ d.

Frame 8
____ a.
____ b.
____ c.
____ d.
____ e.
____ f.
____ g.
____ h.
____ i.
____ j.

Frame 9
____ a.
____ b.
____ c.

Frame 10
____ a.
____ b.
____ c.

Frame 11
____ a.
____ b.
____ c.
____ d.

Frame 12
____ a.
____ b.
____ c.

Frame 13
____ a.
____ b.
____ c.
d. (Turntable, Monitor)
e. (Monitor and Console, Turntable and Console)
f. (¼, ½, 3/4)

Frame 14
____ a.
____ b.
____ c.

Frame 15
____ a.
____ b.
____ c.
____ d.

Frame 16
____ a.
____ b.
____ c.
____ d.
e. (before, after)
f. (is, is not)

Frame 17
No Response

Frame 18
____ a.
____ b.
____ c.

Frame 19
____ a.
____ b.

Frame 20
____ a.
____ b.
____ c.
____ d.
____ e.

Frame 21
No Response

Frame 22
____ a.
____ b.
____ c.

Frame 23
____ 1.
____ 2.
____ 3.
____ 4.
____ 5.

Frame 23 cont on next page

1954

Frame 23 cont

____ 6.

____ 7.

8. (Magnetic field...
remote compass
transmitter)

9. (Monitor...turntable
...console)

10. (azimuth dial...
master sensing unit)

11. (Console...master sensing
unit...remote compass
transmitter)

12. (every 15 degree heading
...the cardinal headings)

Frame 24

____ a.

____ b.

____ c.

Frame 25

____ a.

____ b.

____ c.

Frame 26

____ a.

____ b.

Frame 27

____ a.

____ b.

Frame 28

____ a.

____ b.

Frame 29

____ a.

____ b.

____ c.

Frame 30

____ a.

____ b.

____ c.

Frame 31

____ a.

____ b.

____ c.

____ d.

____ e.

____ f.

Frame 32

____ a.

____ b.

Frame 33

____ a.

____ b.

____ c.

Frame 34

No Response

Frame 35

____ a.

____ b.

____ c.

____ d.

Frame 36

____ a.

____ b.

Frame 37

____ a.

____ b.

____ c.

Frame 38

____ a.

____ b.

____ c.

Frame 39

____ a.

____ b.

____ c.

Frame 40

No Response

7866

Response Sheet 3ABR32531-PT-404
Page 1 of 2

MC-1 COMPASS CALIBRATOR

Frame 1
No Response

Frame 2
____ a.
____ b.
____ c.

Frame 3
No Response

Frame 4
____ a.
____ b.
____ c.

Frame 5
____ a.
____ b.
____ c.

Frame 6
____ a.
____ b.
____ c.

Frame 7
____ a.
____ b.
____ c.
____ d.

Frame 8
____ a.
____ b.
____ c.
____ d.
____ e.
____ f.
____ g.
____ h.
____ i.
____ j.

Frame 9
____ a.
____ b.
____ c.

Frame 10
____ a.
____ b.
____ c.

Frame 11
____ a.
____ b.
____ c.
____ d.

Frame 12
____ a.
____ b.
____ c.

Frame 13
____ a.
____ b.
____ c.
d. (Turntable, Monitor)
e. (Monitor and Console, Turntable and Console)
f. (¼, ½, 3/4)

Frame 14
____ a.
____ b.
____ c.

Frame 15
____ a.
____ b.
____ c.
____ d.

Frame 16
____ a.
____ b.
____ c.
____ d.
e. (before, after)
f. (is, is not)

Frame 17
No Response

Frame 18
____ a.
____ b.
____ c.

Frame 19
____ a.
____ b.

Frame 20
____ a.
____ b.
____ c.
____ d.
____ e.

Frame 21
No Response

Frame 22
____ a.
____ b.
____ c.

Frame 23
____ 1.
____ 2.
____ 3.
____ 4.
____ 5.

Frame 23 cont on next page

Frame 23 cont

____ 6.

____ 7.

8. (Magnetic field...
remote compass
transmitter)

9. (Monitor...turntable
...console)

10. (azimuth dial...
master sensing unit)

11. (Console...master sensing
unit...remote compass
transmitter)

12. (every 15 degree heading
...the cardinal headings)

Frame 24

____ a.

____ b.

____ c.

Frame 25

____ a.

____ b.

____ c.

Frame 26

____ a.

____ b.

Frame 27

____ a.

____ b.

Frame 28

____ a.

____ b.

Frame 29

____ a.

____ b.

____ c.

Frame 30

____ a.

____ b.

____ c.

Frame 31

____ a.

____ b.

____ c.

____ d.

____ e.

____ f.

Frame 32

____ a.

____ b.

Frame 33

____ a.

____ b.

____ c.

Frame 34

No Response

Frame 35

____ a.

____ b.

____ c.

____ d.

Frame 36

____ a.

____ b.

Frame 37

____ a.

____ b.

____ c.

Frame 38

____ a.

____ b.

____ c.

Frame 39

____ a.

____ b.

____ c.

Frame 40

No Response

1868

Response Sheet 3ABR32531-PT-404
Page 1 of 2

MC-1 COMPASS CALIBRATOR

Frame 1

No Response

Frame 2

____ a.

____ b.

____ c.

Frame 3

No Response

Frame 4

____ a.

____ b.

____ c.

Frame 5

____ a.

____ b.

____ c.

Frame 6

____ a.

____ b.

____ c.

Frame 7

____ a.

____ b.

____ c.

____ d.

Frame 8

____ a.

____ b.

____ c.

____ d.

____ e.

____ f.

____ g.

____ h.

____ i.

____ j.

Frame 9

____ a.

____ b.

____ c.

Frame 10

____ a.

____ b.

____ c.

Frame 11

____ a.

____ b.

____ c.

____ d.

Frame 12

____ a.

____ b.

____ c.

Frame 13

____ a.

____ b.

____ c.

d. (Turntable, Monitor)

e. (Monitor and Console, Turntable and Console)

f. (¼, ½, 3/4)

Frame 14

____ a.

____ b.

____ c.

Frame 15

____ a.

____ b.

____ c.

____ d.

Frame 16

____ a.

____ b.

____ c.

____ d.

e. (before, after)

f. (is, is not)

Frame 17

No Response

Frame 18

____ a.

____ b.

____ c.

Frame 19

____ a.

____ b.

Frame 20

____ a.

____ b.

____ c.

____ d.

____ e.

Frame 21

No Response

Frame 22

____ a.

____ b.

____ c.

Frame 23

____ 1.

____ 2.

____ 3.

____ 4.

____ 5.

Frame 23 cont on next page

Frame 23 cont

____ 6.

____ 7.

8. (Magnetic field...
remote compass
transmitter)

9. (Monitor...turntable
...console)

10. (azimuth dial...
master sensing unit)

11. (Console...master sensing
unit...remote compass
transmitter)

12. (every 15 degree heading
...the cardinal headings)

Frame 24

____ a.

____ b.

____ c.

Frame 25

____ a.

____ b.

____ c.

Frame 26

____ a.

____ b.

Frame 27

____ a.

____ b.

Frame 28

____ a.

____ b.

Frame 29

____ a.

____ b.

____ c.

Frame 30

____ a.

____ b.

____ c.

Frame 31

____ a.

____ b.

____ c.

____ d.

____ e.

____ f.

Frame 32

____ a.

____ b.

Frame 33

____ a.

____ b.

____ c.

Frame 34

No Response

Frame 35

____ a.

____ b.

____ c.

____ d.

Frame 36

____ a.

____ b.

Frame 37

____ a.

____ b.

____ c.

Frame 38

____ a.

____ b.

____ c.

Frame 39

____ a.

____ b.

____ c.

Frame 40

No Response

1870

PREPARE THE MAN

PROGRAMMED TEXT 3ABR32530-1-PT-206A
3ABR32531-PT-404A
3ABR32632B-PT-502E

Technical Training

Automatic Flight Control Systems Specialist
Avionics Instrument System Specialist
Integrated Avionics System Specialist

AZIMUTH DIAL READINGS (MC-1 CALIBRATOR)

28 June 1974

AIR TRAINING COMMAND

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR32530-1-PT-206A, 10 October 1973.
OPR: TAS
DISTRIBUTION: X
TAS - 1500; TTOC - 4

Designed For ATC Course Use

DO NOT USE ON THE JOB

1960

1871

FOREWORD

This programmed text was developed for use in Course 3ABR32530-1, Automatic Flight Control Systems Specialist. The material herein was validated by 26 students in the subject course. At least 90% of the students achieved the objective as stated. Average time required to complete this text is 21 minutes.

OBJECTIVES

Using illustrations of the compass calibrator azimuth dial, interpret the readings on the vernier scales without error.

INSTRUCTIONS

The information in this program is presented in small steps called "frames." Each frame is followed by some form of questioning. Immediately after reading each frame, make the required response. The correct answer will be found at the beginning of the next frame. Check your answer each time. If you make an incorrect response, read the frame again. If the response is correct, continue to the next frame.

Frame 1

Performing compass swings using the MC-1 compass calibrator requires reading vernier scales on the azimuth dials. The accuracy of this type of compass swing depends a great deal on the ability of the user to accurately read these scales. The following frames are designed to explain how to read the azimuth dials in degrees and minutes. The degree and minute readings are used as magnetic headings and references throughout the swing procedure.

NO RESPONSE REQUIRED.

Answer to Frame 1: None required.

Frame 2

The MC-1 azimuth scales are calibrated in degrees and minutes. The smallest division represents 30 minutes (30'). The azimuth scales are equipped with verniers that read in minutes. Each division on the vernier scale represents 1 minute.

Circle the letter(s) of the true statement(s) below.

1. The azimuth scale is graduated in increments of 30 minutes.
2. The smallest division on the vernier scale represents 1 second.
3. The vernier scale is calibrated in minutes only.

1963

Answers to Frame 2: [✓ 1.] 2. [✓ 3.]

Frame 3

Refer to figure 1 below. All headings on the azimuth scale are referenced to the index (Y) on the vernier scale. The heading on the azimuth scale below is exactly 000° or 360°. The first division to the right of 000 degrees is 30 minutes less than 360 degrees and of course the first division to the left is 30 minutes more than 000 degrees.

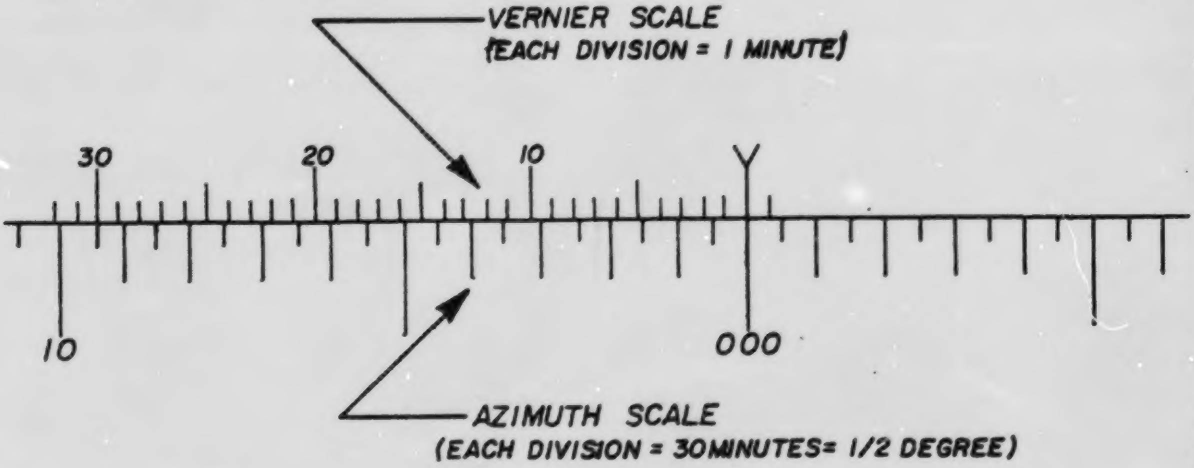

VERNIER SCALE
(EACH DIVISION = 1 MINUTE)
30
20
10
Y
10
000
AZIMUTH SCALE
(EACH DIVISION = 30MINUTES= 1/2 DEGREE)

Figure 1.

Circle the letter(s) of the true statement(s) below.

1. The azimuth scale is referenced to the index on the vernier scale.
2. The first division on the azimuth scale to the right of the index indicates a reading less than 300 degrees.
3. The smallest increment on the azimuth scale represents 1/2 of a degree.

1875

Answers to Frame 3: [✓ 1.] 2. [✓ 3.]

Frame 4

The importance of accurately reading the MC-1 azimuth scales cannot be overemphasized. Probably the best way to achieve a high degree of accuracy is to follow some sequence for taking these readings. Refer to figure 2 while following the instructions below in order to establish this sequence.

STEP 1. Determine which NUMBERED division on the azmimuth scale is referenced closest to the vernier index.

STEP 2. Next, add the number of degrees on the azimuth scale that appears to the right of the index up to the NUMBERED degree.

Using figure 2 as a reference, circle the correct word(s) in each statement below.

1. There is (less, more) than 1 degree that appear(s) to the right of the index up to the NUMBERED degree.
2. The heading on the azimuth scale is (less, more) than 80 degrees.

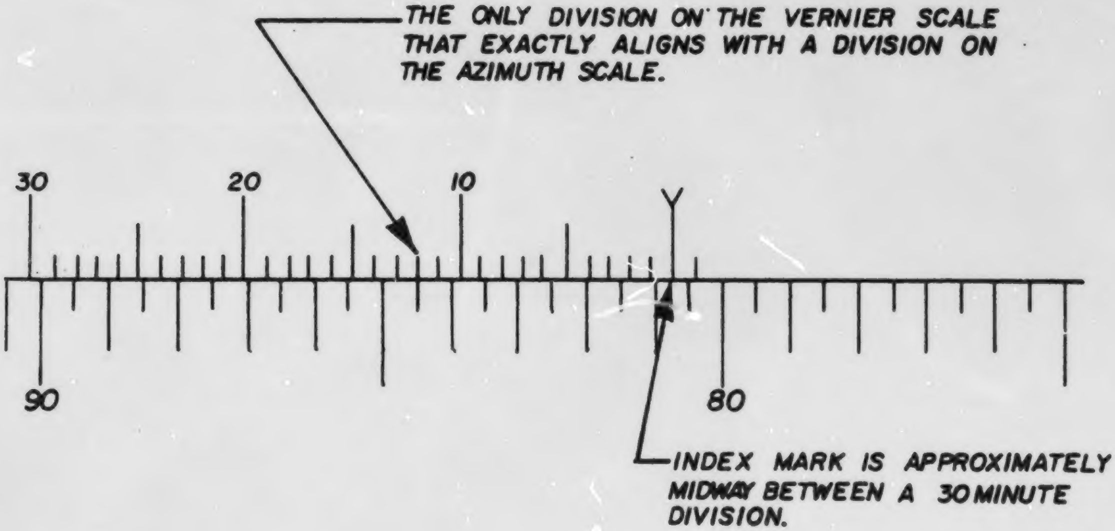

THE ONLY DIVISION ON THE VERNIER SCALE THAT EXACTLY ALIGNS WITH A DIVISION ON THE AZIMUTH SCALE.
30
20
10
Y
90
80
INDEX MARK IS APPROXIMATELY MIDWAY BETWEEN A 30 MINUTE DIVISION.

Figure 2.

1965

Answers to Frame 4: 1. less 2. more

Frame 5

Thus far, you know that the heading is 80 degrees and more than 30 minutes. Refer to figure 2 again. Notice that the index is halfway between divisions. This indicates an amount close to 15 minutes and brings us to the next step.

STEP 3. Focus your eyes on the vernier scale near the 15 minute division. Notice that there is only one division on the vernier that EXACTLY aligns with a division on the azimuth scale.

STEP 4. Add this amount to the 80 degrees and 30 minutes and you have the EXACT heading indicated on the azimuth dials.

Refer to figure 2 and fill in the blank space(s) in the statements below with the correct words or numbers which complete the statements.

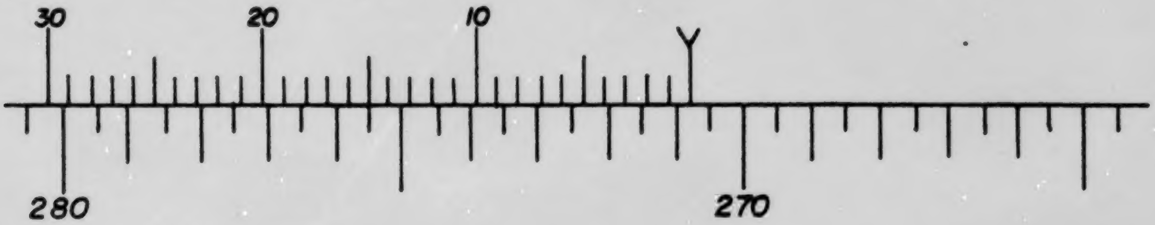
1. The only division on the vernier scale that EXACTLY ALIGNS with a division on the azimuth scale is the ________ minute division.

2. The EXACT heading is: __________ degrees and __________ minutes.

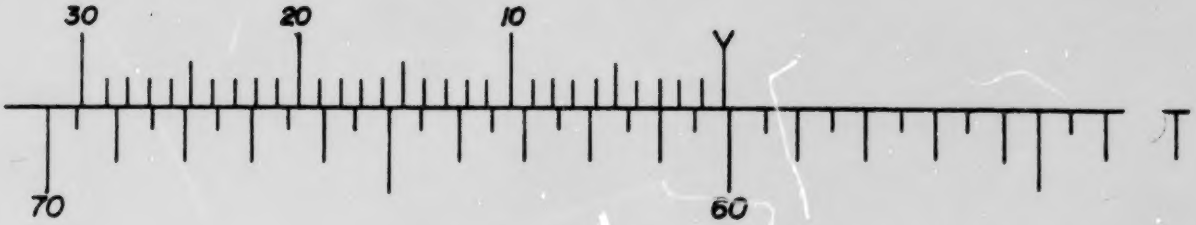
Answers to Frame 5: 1. twelve (12), 2. eighty (80), forty-two (42)

Frame 6

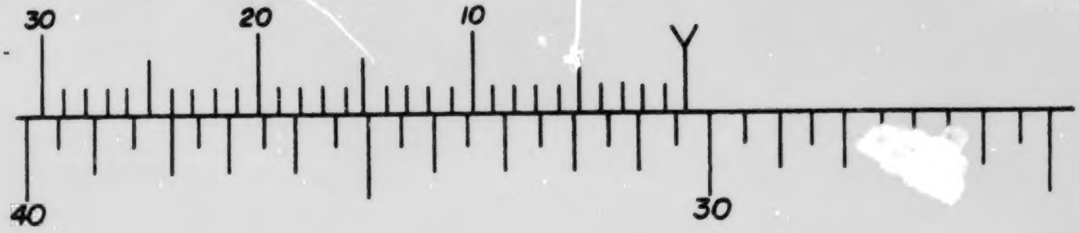
To gain proficiency in reading azimuth scales accurately perform the following four exercises and record your reading in the space provided below each exercise.


30
20
10
Y
280
270

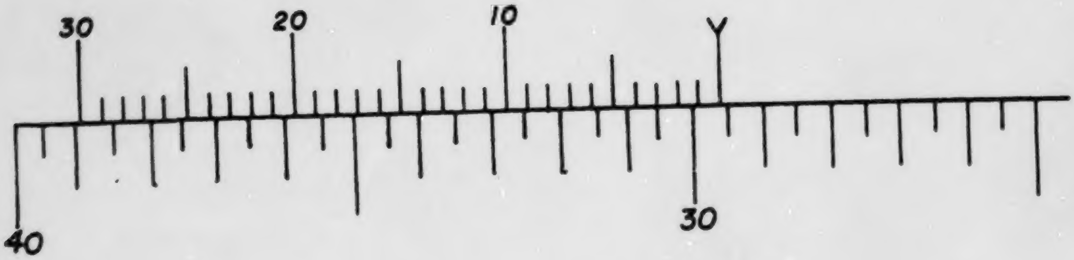
EXERCISE NO 1 ________________


30
20
10
Y
70
60

EXERCISE NO 2 ________________


30
20
10
Y
40
30

EXERCISE NO 3 ________________


30
20
10
Y
40
30

EXERCISE NO 4 ______________

Answers to Frame 6:

EXERCISE NO 1.	270° 45'
EXERCISE NO 2.	60° 3'
EXERCISE NO 3.	30° 24'
EXERCISE NO 4.	29° 33'

Frame 7

The azimuth scales on the turntable, monitor, and console are all read the same way. The vernier scale can be rotated independently of the azimuth scale or the azimuth and vernier can be locked together and rotated within the tripod as a unit.

NO RESPONSE REQUIRED.

If you missed any of the exercises in Frame 6, read the text again. When you are finished, ask the instructor for the examination.

Instrument Branch
Chanute AFB, Illinois

3ABR32531-WB-404
3ABR32632B-WB-502B
6 August 1974

USE OF THE MC-1 COMPASS CALIBRATOR

OBJECTIVES

Using a trainer, workbook, technical order, AFTO Form 53, and a MC-1 compass calibrator set, perform a compass swing and compensation adjustment IAW the procedures in the TO. You will be allowed no more than 10 instructor assists for performance and recording of data in each section of the AFTO Form 53.

To accomplish this objective, you will require the following equipment.

EQUIPMENT

	Basis of Issue
MC-1 Compass Calibrator Set	1/2 students
Trainer, AFRS	1/2 students
Adapter Kit, MC-1	1/2 students
TO 5N3-3-7-1	1/student
AFTO Form 53	1/2 students

PROCEDURES

Perform each step in the following list of procedures in the sequence listed. DO NOT OMIT or perform any step out of sequence.

1. Caution: Remove your jewelry and any ferrous material that you may have on your person.

2. Select TO 5N3-3-7-1 from the technical order file; turn to Section IV, paragraph 4-41, Equipment Set-Up. Follow the instructions to set up the equipment for performing the compass swing.

3. Obtain an AFTO Form 53 from your instructor. Turn to page 1 and complete the data required at the top of the page: LOCATION: Chanute AFB, AIRCRAFT: F-111, COMPASS SYSTEM: Gyro Stabalized, TRANSMITTER PART NO.: (No. of TX on turntable), SERIAL NO.: (No. of TX on turntable).

4. Determine initial magnetic bearing of N-S line (refer to TO 5N3-3-7-1, paragraph 4-42).

This supersedes 3ABR32531-PT-405B, 3ABR32632B-PT-405B, 17 August 1973.
OPR: TAS
DISTRIBUTION: X
TAS - 750; TTOC - 3

Designed for ATC Course Use. Do Not Use on the Job.

5. Magnetic north alignment of the transmitter (refer to TO 5N3-3-7-1, paragraph 4-44).

6. Determine the E1 and E2 voltages for the transmitter (refer to TO 5N3-3-7-1, paragraphs 4-45 through 4-50).

7. Determine the transmitter Δ180 and Δ270 crosstalk values (refer to TO 5N3-3-7-1, paragraph 4-51).

8. Optical transfer of the transmitter (refer to TO 5N3-3-7-1, paragraph 4-52).

a. Mount the optical alignment equipment on the transmitter and sight the target as per instructions in the TO.

b. Position the AFRS trainer onto the N-S line.

Note: We will assume that the trainer is one-tenth the size of the aircraft, therefore all measurements will be based on a 10 to 1 ratio.

9. Electrical swing of aircraft remote compass transmitter (one cycle error). Refer to the specific aircraft TO for correct procedures.

a. An electrical compass swing is performed to determine the error due to magnetic materials or direct current fields in the vicinity of the remote compass transmitter.

b. Disconnect the harness on the remote compass compensator.

c. Make the following connections:

(1) Connect P1 of cable W1 to the remote compensator.

(2) Connect P2 of cable W1 to the turntable cable from the console of the MC-1 (P104 of W102).

(3) Connect J1 of cable W1 to P5 of cable W4.

(4) Connect J4 of W4 to the aircraft harness at the remote compensator.

d. Disconnect the aircraft harness from J3 of the ECA.

e. Leave the field monitor at the field monitor location and leave it connected to the console.

f. Position all the controls and switches to their OFF or zero positions.

g. Place the E1 switch to E1 NORM; place the E2 switch to E2 NORM.

h. Place the Power Switch to ON. Check the voltmeter and freqmeter for the correct indications (23.5 VAC and 400 Hz).

1971

i. Rotate the MODE SELECTOR to MON. Use the SYNCHRO CONTROL knobs to zero the null indicator. Record the synchro dial reading on line F-1 of the data sheet.

j. Enter the MISAL control setting on line F-2 of the data sheet. The MISAL control setting is determined by adding the aircraft misalignment (E-5), field monitor index (A-4), and field monitor reading (F-1), and subtracting the field monitor zero error reading (A-5). Rotate the MISAL control on the console to the calculated setting.

k. Enter the 180 and 270 correction values on lines F-3 and F-4 of the data sheet. Rotate the 180 and 270 controls to the respective settings. Enter the E-1 check (C-3) and E-2 check (C-4) values in the spaces provided in the electrical swing portion of the data sheet. Rotate the E-1 CHECK and E-2 CHECK controls to their respective settings.

l. Rotate the HDG SELECTOR to 0. Adjust the synchro dial to 90. Position the E-1 - E-2 CHECK switch to the E-1 CHECK and adjust the E-1 voltage controls to zero the null indicator. Place the E-1 - E-2 CHECK to the E-2 position and adjust the E-2 voltage controls to zero the null indicator. Position the E-1 - E-2 CHECK switch to OFF.

m. Rotate the MODE SELECTOR to CAL. Position the HDG SELECTOR to 0 and the SYNCHRO DIAL to 0. Adjust the N-S compensator screw to zero the null indicator.

n. Position the HDG SELECTOR to 90 and turn the SYNCHRO DIAL to 90. Adjust the E-W compensation screw to zero the NULL INDICATOR.

o. Rotate the HDG SELECTOR to headings of 0, 90, 180, and 270 degrees. At each heading, use the SYNCHRO DIAL to zero the null indicator. Record two errors for each of the four headings in the ONE-CYCLE ERROR table F-1 of the AFTO Form 53.

p. Average the two readings at each heading and record the average. Use the average errors to compute the ONE-CYCLE error of the compass system as follows:

$$\text{N-S Error} = \frac{E_0 - E_{180}}{2} \qquad \text{E-W Error} = \frac{E_{90} - E_{270}}{2}$$

q. To correct for this error, rotate the HDG SELECTOR to 0. Increase or decrease the SYNCHRO DIAL setting from a heading of 0 by an amount equal to but opposite, in algebraic sign, to the amount of the N-S error. Adjust the N-S compensator screw on the remote compensator to zero the null indicator.

r. Rotate the HDG SELECTOR to 90. Increase or decrease the SYNCHRO DIAL setting from a heading of 90 by an amount equal to but opposite in algebraic sign to the amount of E-W error. Adjust the E-W compensator screw on the remote compensator to zero the null indicator.

s. Perform a corrected electrical swing by rotating the HDG SELECTOR to headings at 30 degree increments. Begin with 0, 30, 60, etc. At each heading, zero the null indicator using the SYNCHRO DIAL. The difference between the HDG SELECTOR and the SYNCHRO DIAL is the error. Record the errors on the data sheet.

t. If any errors recorded in the corrected electrical swing just performed exceeds 30 minutes, the swing is not acceptable. An unacceptable swing shall be corrected by repeating steps m through r.

10. The following information is limited to compensating the swing adjustments between the AFRS trainer compass system and the remote compass transmitter.

a. Disconnect POWER from the CONTROL CONSOLE. Place the MODE SELECTOR to COMP.

b. Connect J3 to the ECA.

c. Remove cable W4 from between the remote compensator and the aircraft harness. Connect the aircraft harness cable (W1) to the remote compensator.

d. Connect 28V DC and 115V AC, 3 phase, 400 Hz to the AFRS trainer. Prepare the trainer for operation. Place the AC POWER, DC POWER and GYRO switches ON. (Allow sufficient time for the system to warm up.)

e. Place the power switch on the CONTROL CONSOLE to ON.

f. Rotate the HDG SELECTOR to each 15 degree setting and adjust the 24 point compensator for the appropriate heading. (Note: Watch the HSI while making these adjustments.)

g. This completes the training on the MC-1 compass calibrator. Request further instructions from your instructor.

MC-1/MC-1M COMPASS SWING DATA SHEET

LOCATION

AIRCRAFT TYPE	COMPASS SYSTEM	TRANSMITTER PART NUMBER	SERIAL NUMBER

SWITCH AND CONTROL SETTINGS

△180, △270, MISAL to 0.
HDG. SELECTOR to 0 DEGREES.
E1-E2 CHECK to OFF.
E1, E2 VOLTS to OFF.
MODE SELECTOR to MON.
READOUT SELECT (MC-1M) to FV.
TRANSMITTER SELECT (MC-1M) as required.
POWER ON-OFF to POWER ON.
EX. VOLTS to 23.5.
SYNCHRO CONTROL (MC-1) to null at each heading in table A.

SECTION A CHECK THE MAGNETIC BEARING AT THE MONITOR LOCATION (para 4-42)

Table A

Monitor Heading	Readout Error
0	
90	
180	
270	
Algebraic Sum	

Data

REFERENCE TARGET BEARING (para 4-42a) ________ A-1
MONITOR INDEX ERROR (para 4-43d) = $\frac{\text{Algebraic Error Sum}}{4}$ ________ A-2
TURNTABLE LOCATION CORRECTION (para 4-43e) ________ A-3
CORRECTED MONITOR INDEX (A-2) + (A-3) (para 4-43e) ________ A-4
MONITOR ZERO ERROR (para 4-43f) ________ A-5

Change: MODE SELECTOR to CAL..

SECTION B ALIGN THE TRANSMITTER MAGNETICALLY (para 4-44)

Table B

Turntable Heading	Readout Errors					Corrected Manual [Avg Minus Index (B-1)]
	Initial	1st	2nd	3rd	Avg	
0						
90						
180						
270						
Algebraic Sum						

TRANSMITTER INDEX ERROR (para 4-44k)

$\frac{\text{Algebraic Sum}}{4}$ ________ B-1

NOTE
Correct Index until error is within ±15 minutes.

1974

1975

1884

Change: MODE SELECTOR to MON.

Monitor Zero Error (para 4-44k) ________ B-2

AFTO FORM JUL 70 53 FC 4420 PREVIOUS EDITION WILL BE USED.

Change: MODE SELECTOR to CAL.
E1, E2 VOLTS as specified in tables C1 and C2
HDG. SELECTOR to 90 DEGREES.
SYNCHRO CONTROL (MC-1) as specified in tables C1 and C2
READOUT SELECT (MC-1M) as specified in tables C1 and C2.

SECTION C DETERMINE THE E1 AND E2 VOLTAGES FOR THE TRANSMITTER (para 4-45)

Table C1	E2	Table C2	E1
E1 to OFF E2 to NORM. READOUT to 0 TURNTABLE 270		E1 to REV. E2 to OFF READOUT to 90 TURNTABLE 180	
E2 to REV. READOUT to 0 TURNTABLE 90		E1 to NORM. READOUT to 90 TURNTABLE 0	
Algebraic Sum		Algebraic Sum	

$\text{E2 AVERAGE} = \frac{\text{E2 Algebraic Sum}}{6}$

(para 4-48e) ________ C-1

$\text{E1 AVERAGE} = \frac{\text{E1 Algebraic Sum}}{6}$

(para 4-49f) ________ C-2

Change: MODE SELECTOR to MON.
E1, E2 to NORM.
E1 VOLTS to C-2.
E2 VOLTS to C-1
E1-E2 CHECK as required.
SYNCHRO CONTROL (MC-1) to 90.
READOUT SELECT (MC-1M) to 90.

E1 CHECK CONTROL SETTING, E1-E2 CHECK switch to E1 CHECK (para 4-50b) ________ C-3

E2 CHECK CONTROL SETTING, E1-E2 CHECK switch to E2 CHECK (para 4-50c) ________ C-4

Change: E1-E2 CHECK to OFF.
SYNCHRO CONTROL (MC-1) to null.
READOUT SELECT (MC-1M) to FV.

SECTION D DETERMINE THE △180 AND △270 VALUES (para 4-51)

MONITOR ZERO ERROR (para 4-51b) ________ D-1

MISAL CONTROL SETTING; (B-1) + (D-1) — (B-2) (para 4-51c) ________ D-2

Change: MODE SELECTOR to CAL.
E1 VOLTS to C-2
E2 VOLTS to C-1
MISAL to D-2
HDG. SELECTOR as indicated
SYNCHRO CONTROL to null.
E1, E2 to NORM.

(TURNTABLE to 0 heading.)

Table D

HDG. SELECTOR	Readout Error				Corrected Manual Swing Value (from table B)	(E - M) Electrical Error minus Manual Error	Corrected Electrical Swing
	1	2	3	Avg			
0							
90							
180							
270							

$\triangle 180 = E - M_{180}$ (para 4-51j) ________ D-3

$\triangle 270 = E - M_{90} + E - M_{270}$ (para 4-51j) ________ D-4

$E - M_{90}$ shall be equal to $E - M_{270} \pm 9$ minutes; if not, repeat sections B and C.

1976

1977

SECTION E OPTICAL TRANSFER OF THE TRANSMITTER (para 4-52)

PLUMB BOB SEPARATION along aircraft (para 4-53i) ________ E-1

Displacement of nose of aircraft from N-S line (para 4-53j) ________ E-2

Displacement of tail of aircraft from N-S line (para 4-53j) ________ E-3

PLUMB BOB TOTAL DISPLACEMENT (E-2) - (E-3) (para 4-53k) ________ E-4

AIRCRAFT MISALIGNMENT WITH N-S line (para 4-53l) ________ E-5

OPTICAL ALIGNMENT CORRECTION (PARA 4-53m) AIRCRAFT MISALIGNMENT
(E-5) + (A-4) + (B-2) - (A-5) - (B-1) ________ E-6

SECTION F COMPASS SWING (para 4-54)

SWITCH AND CONTROL SETTINGS	DATA
E1, E2 to NORM. E1-E2 CHECK to OFF. MODE SELECTOR to MON. HDG. SELECTOR to 0. SYNCHRO CONTROL (MC-1) to NULL. READOUT SELECT (MC-1M) to FV. E1 CHECK to C-3. E2 CHECK to C-4	MONITOR ZERO ERROR (para 4-54e) ________ F-1 MISAL CONTROL SETTING: (E-5) + (A-4) + (F-1) - (A-5) (para 4-54f) ________ F-2 Δ 180 correction value (from D-3) ________ F-3 Δ 270 correction value (from D-4) ________ F-4 E1 CHECK CONTROL SETTING (from C-3) ________ F-5 E2 CHECK CONTROL SETTING (from C-4) ________ F-6 (para 4-54g)
Change: SYNCHRO CONTROL to 90. READOUT SELECT to 90. E1, E2 VOLTS to null NULL INDICATOR.	E1 recorded with E1-E2 CHECK in E1 CHECK ________ F-7 E2 recorded with E1-E2 CHECK in E2 CHECK ________ F-8 (para 4-54i)
Change: E1-E2 CHECK to OFF. MISAL to F2. MODE SELECTOR as required. HDG. SELECTOR as required. SYNCHRO CONTROL (MC-1) as required. READOUT SELECT (MC-1M) as required.	INDEX AND ONE-CYCLE ERROR COMPENSATION (para 4-55)

Table F1

HDG. SELECTOR.	SYSTEM READOUT ERROR			
	1	2	3	4
0				
90				
180				
270				

$$\text{Index} = \frac{E_0 + E_{90} + E_{180} + E_{270}}{4}$$

$$\text{N-S Error} = \frac{E_0 - E_{180}}{2}$$

$$\text{E-W Error} = \frac{E_{90} - E_{270}}{2}$$

1886.

1979

1978

AFTO FORM JUL 70 53 FC 4420 PREVIOUS EDITION WILL BE USED.

SYSTEM ERROR COMPENSATION

(para 4-56)

Table F2

HDG. SELECTOR	SYSTEM READOUT ERROR			HDG. SELECTOR	SYSTEM READOUT ERROR			HDG. SELECTOR	SYSTEM READOUT ERROR		
	1	2	3		1	2	3		1	2	3
0				120				240			
15				135				255			
30				150				279			
45				165				285			
60				180				300			
75				195				315			
90				210				330			
105				225				345			

1888

PROGRAMMED TEXT
3ABR32531-PT-405

Technical Training

Avionics Instrument Systems Specialist

ELECTRONIC TEST EQUIPMENT

19 November 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

1981

1889

OBJECTIVE

Without reference, select statements pertaining to the operation of electronic test equipment.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Each section allows you to proceed stepbystep through the material. Each step teaches you a small amount of material and then asks you to respond to that information. Read the information and respond as directed. Confirmation to your responses are given at the bottom of the following frame. Do not proceed until you have responded correctly. If you need assistance, see your instructor.

DO NOT HURRY!

Supersedes 3ABR32531PT403A, 12 January 1978, which may be used until existing stocks are depleted.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGUF - 300; TTVSA 1

1982

When checking aircraft system components, it is necessary to use various pieces of test equipment. Some test equipment is designed to check specific components or a specific system. The AFRS Line Analyzer is an example of factory designed test equipment with a specific purpose. Other test equipment is used on a wide range of components or systems. The PSM/6 is an example of general test equipment. The electronic test equipment you will use in the lab and will study is general test equipment.

Circle the number(s) of the true statement(s) below.

1. Electronic test equipment is factory designed to be used with a specific system.

2. Electronic test equipment is considered as general test equipment.

DC DIGITAL VOLTMETER

Frame 2

Page 3 shows a piece of test equipment used in the lab. The power requirements for the electronic test equipment in the lab is 115 volts 60Hz.

Circle the letter of the correct answer below.

1. The power requirement(s) for the DC digital voltmeter is

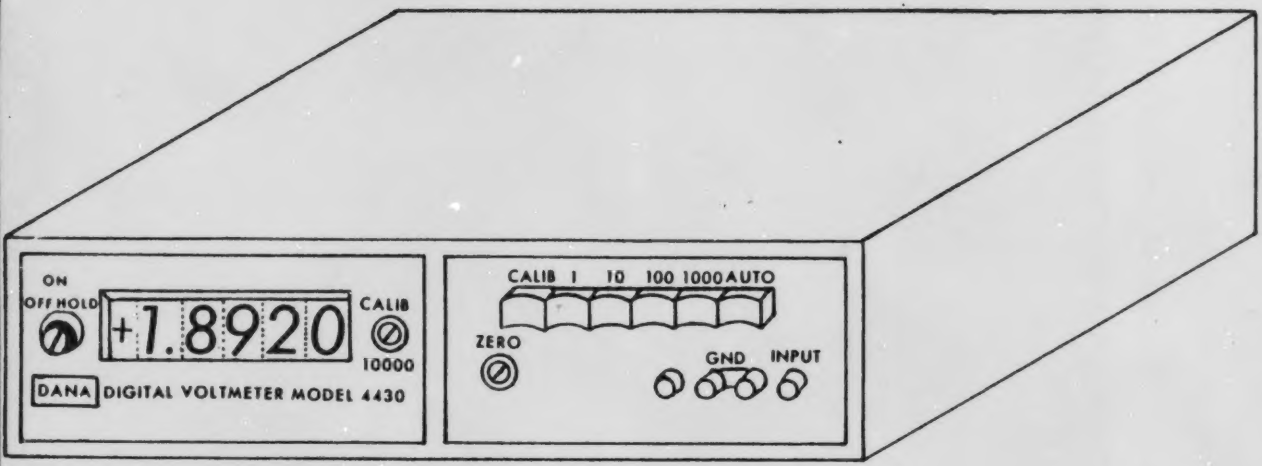
   a. 28V DC.

   b. 115V, 60Hz.

   c. 115V, 400Hz.

   d. 115V, 400Hz and 28V DC.

The correct answer to Frame 1 is: 1 [✓ 2]


ON
OFF HOLD
+1.8920
CALIB
10000
DANA
DIGITAL VOLTMETER MODEL 4430
CALIB
1
10
100
1000
AUTO
ZERO
GND
INPUT

1985

Frame 3

The DC digital voltmeter (shown on page 3) is actually a vacuum tube voltmeter connected to a digital display. The purpose of this voltmeter is to measure and give a digital reading of DC voltage. When checking transistorized components, the DC digital voltmeter is used in place of the PSM/6 because the PSM/6 causes enough circuit loading to make its readings inaccurate.

Place a checkmark (✓) in front of true statements below.

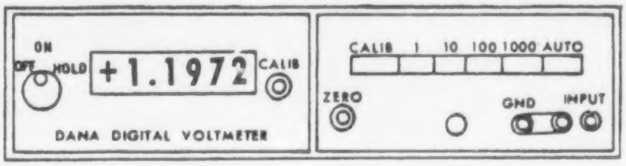
_____1. The DC digital voltmeter is a vacuum tube voltmeter.

_____2. The DC digital voltmeter is used to measure DC voltage, milliamperes, and resistance.

_____3. The DC digital voltmeter is used when checking transistorized components because of less circuit loading.

Answer to Frame 2: a [✓ b] c d

There are two modules on the DC digital voltmeter, the DIGITIZING AND DISPLAY MODULE and the ACCESSORY MODULE. (See figure below.) We will first cover the DIGITIZING AND DISPLAY MODULE. This portion of the voltmeter contains a power switch, digital display, and calibrate adjustment.


ON
OFF
HOLD
+1.1972
CALIB
DANA DIGITAL VOLTMETER
CALIB 1 10 100 1000 AUTO
ZERO
GND
INPUT

1. In the spaces provided, write the two names of the voltmeter modules.

   ____

   ____

2. Complete the statement below by underlining the correct response.

   The power switch, digital display, and calibrate adjustment are located on the (digitizing and display module, accessory module).

The correct answer to Frame 3 is: __✓__ 1. _____ 2. __✓__ 3.

1895

Frame 5

Use the figure below to locate the part of the digitizing and display module as they are explained.

POWER SWITCH -

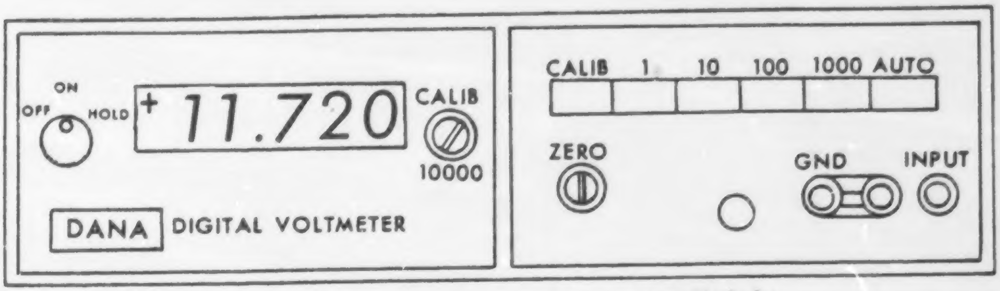
a. OFF - all power is removed from the voltmeter.

b. ON - the voltmeter is operating and taking readings.

c. HOLD - "freezes" the last reading of the voltmeter until it is switched back to the ON position. This allows the voltmeter to remain warmed up without imposing wear on its switches and relays.

DIGITAL DISPLAY - provides a visual readout of the voltage level at the input.

CALIBRATE ADJUSTMENT - used to calibrate the voltmeter to 10,000 after it has warmed up.



Digitizing and Display Module Accessory Module

Place a checkmark (✓) in front of the true statements below.

_____1. The HOLD position of the POWER switch freezes the reading.

_____2. The calibrate adjustment is located on the accessory module.

_____3. Voltage readings are taken from the digital display.

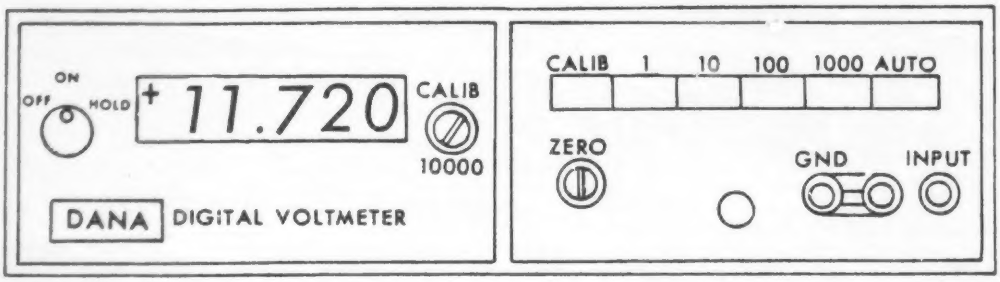
The correct answers to Frame 4 are:

1. Digitizing and display module, accessory module.

2. Digitizing and display module.

1988

When reading the DC digital voltmeter the entire reading is shown in one picture on the face of the meter as shown in the figure below. A decimal point is incorporated in the digital display. Positive or negative voltage is indicated by a polarity sign (+) (-) which precedes the digital display.


ON
OFF
HOLD
+ 11.720
CALIB
10000
DANA DIGITAL VOLTMETER
CALIB
1
10
100
1000
AUTO
ZERO
GND
INPUT

Digitizing and Display Module

Accessory Module

Circle the letter(s) of the correct answer(s) below.

The reading shown on the DC digital voltmeter in figure 4 is

a. +1.1720.

b. -11720.

c. -1.1720.

d. +11.720.

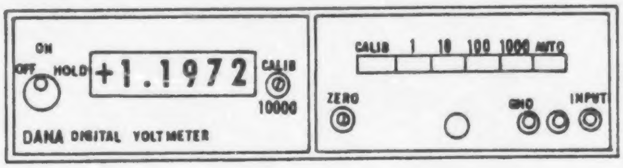
The correct answers to Frame 5 are: ✓ 1. ___ 2. ✓ 3.

Frame 7

Use the figure below to locate the accessory module controls as they are explained.

CALIBRATE (CALIB) SWITCH: This switch is the first one on the left end of the six pushbutton switches. When depressed, it causes a test reading (10000) to appear on the display readout. This reading remains on the display as long as the switch is depressed.

ZERO ADJUSTMENT: To zero the voltmeter, short the two INPUT leads together (located on the bottom right of the DC voltmeter), and select AUTO range. Adjust the ZERO potentiometer for a readout display of 00000.



Match the controls in column A to its function or purpose in column B by placing the appropriate letter from column B in the space provided in front of each control.

COLUMN A	COLUMN B
_____1. Calibrate Switch	a. Is interlocked until another switch is depressed.
_____2. Zero Adjustment	b. Provides a test reading of 10000.
	c. Is depressed to select a desired range.
	d. Used to adjust the readout display to 00000.

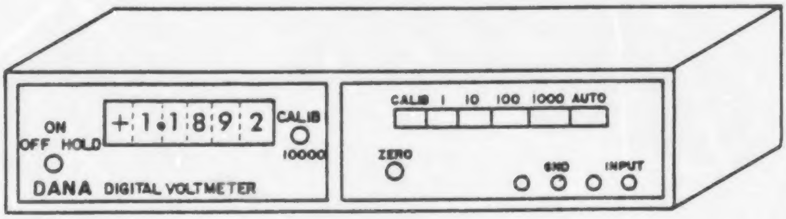
The correct answer to Frame 6 is: ⓓ

Use the figure below to locate the accessory module controls as they are explained.

RANGE CONTROL - The range control consists of the remaining five pushbutton switches on the accessory module. These switches are located to the right of the calibrate (CALIB) switch and are labeled 1, 10, 100, 1000 and AUTO. Because these switches are interlocking, when one switch is depressed the previously used switch returns to the open position.

MANUAL RANGES - Ranges are selected by depressing the switch for the range desired (1, 10, 100, 1000).

AUTO RANGE - This switch allows the voltmeter to automatically select the range that provides the highest accuracy for the voltage being measured.



Match the controls in column A to its purpose or function in column B by placing the appropriate letter from column B in the space provided in front of each control.

COLUMN A	COLUMN B
_____1. Range Switches	a. Used to calibrate the voltmeter to 10000.
_____2. Manual Ranges	b. Labeled 1, 10, 100, 1000, and AUTO.
_____3. Auto Range	c. Provides automatic ranging.
	d. Selected by depressing a switch for the range desired.

Answers to Frame 7: __b__1. __d__2.

Frame 9

Circle the letter of the correct answer(s) below.

1. The purpose of the DC digital voltmeter is to
   a. measure and give a digital reading of DC voltages.
   b. measure current flow in transistorized components.
   c. provide a digital reading of AC voltage in transistorized circuitry.
   d. replace the PSM/6 during voltage and resistance checks.

Circle the letter of the readings that are correct for the display.

2. +00.760
   a. +7.6V DC.
   b. -7.6V DC.
   c. +760 millivolts DC.
   d. -760 millivolts DC.

3. -0.0010
   a. -0.1V DC.
   b. -0.01V DC.
   c. +0.001V DC.
   d. -0.001V DC.

4. +10.101
   a. +10V DC.
   b. +10.101V DC.
   c. +1010.1V DC.
   d. -10.101V DC.

5. -00.008
   a. -0.008 millivolts DC.
   b. -8 millivolts DC.
   c. -80 microvolts DC.
   d. +8 microvolts DC.

Frame 9 (Cont'd)

Match the controls in column B to their purpose or function in column A by placing the appropriate letter in the space provided in front of each purpose.

	COLUMN A		COLUMN B
_____6.	Selected by depressing the switch for the range desired.	a.	AUTO Range.
		b.	Range Switches.
_____7.	Labeled 1, 10, 100, 1000 and AUTO.	c.	Manual Ranges.
_____8.	Provides a test reading of 10000.	d.	Calibrate (CALIB) Switch.
_____9.	Provides automatic ranging.	e.	ZERO Adjustment.
_____10.	Used with AUTO range to adjust the display to 00000.	f.	Calibrate Adjustment.

The answers to Frame 8 are: b 1. d 2. c 3.

Note: The answers to Frame 9 will be verified by the instructor.

PHASE ANGLE VOLTMETER

Frame 10

The phase angle voltmeter shown on page 13 is a dual purpose instrument; (1) it functions as a standard vacuum tube voltmeter for measuring AC voltage, and (2) it measures the phase angle between two input test voltages. The phase angle voltmeter requires a 15-minute warmup, because it uses vacuum tubes in its operation.

Circle the letter of the correct answer below.

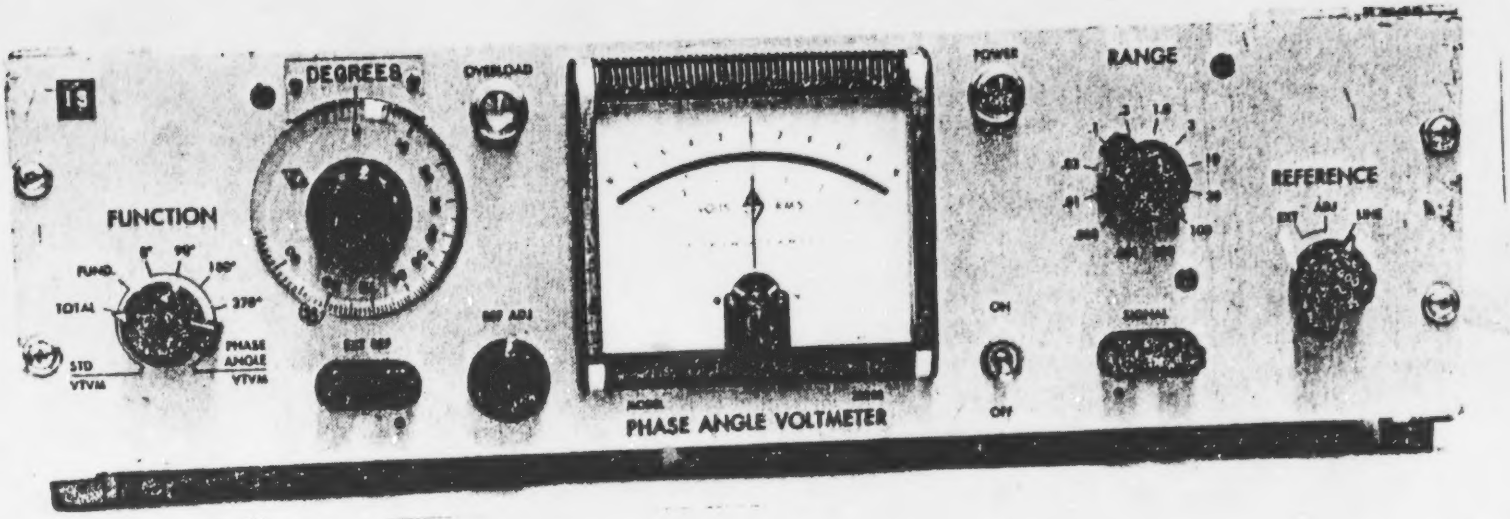
1. The two purposes of the phase angle voltmeter are measuring

    a. frequency and time.

    b. AC current and DC voltage.

    c. the phase angle between two input voltages and AC voltage.

    d. the phase angle between two input voltages and DC voltages.


DEGREES
OVERLOAD
FUNCTION
FUND.
TOTAL
0°
90°
180°
270°
STD
VTVM
PHASE
ANGLE
VTVM
EXT REF
REF ADJ
VOLTS RMS
MODEL
PHASE ANGLE VOLTMETER
POWER
ON
OFF
RANGE
.001
.01
.03
.1
.3
1.0
3
10
30
100
300
SIGNAL
REFERENCE
EXT
ADJ
LINE

1995

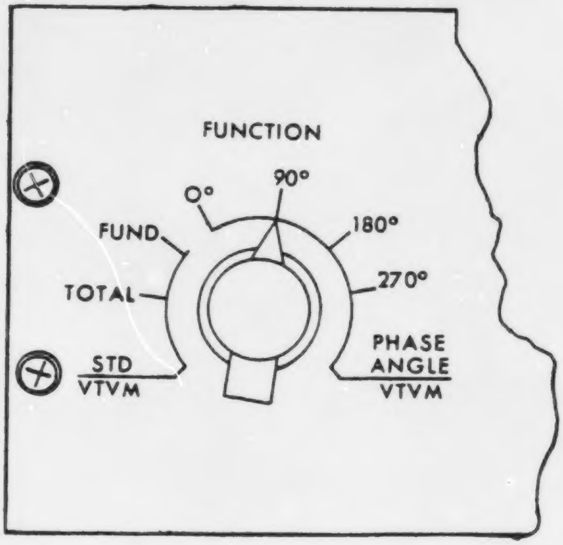
1996

1902

1903

Frame 11

The Function Selector Switch located on the far left side of the voltmeter provides a means for selecting whether the instrument will function as a standard vacuum tube voltmeter or a phase angle voltmeter. (See figure below.) Two positions are provided on the function selector switch for standard voltmeter (STD VTVM) operations; (1) TOTAL, (2) FUND. There are four positions provided for phase angle voltmeter (VTVM) operations, (1) 0°, (2) 90°, (3) 180°, (4) 270°.



Circle the letter of the correct answer below.

1. The FUNCTION selector switch is placed in the TOTAL position to measure

   a. voltage.

   b. current.

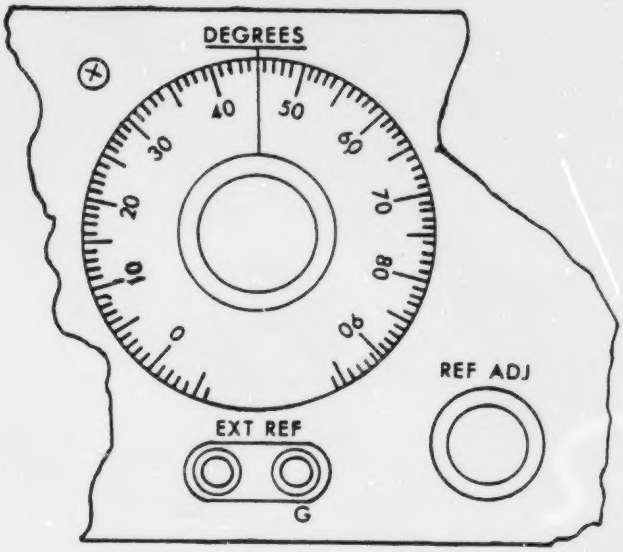
   c. resistance.

   d. phase angle.

The answer to Frame 10 is: ⓒ

Frame 12

Located to the right of the FUNCTION selector switch is a DEGREES dial. This dial is calibrated in one degree increments. It is used in conjunction with the FUNCTION selector switch for measuring phase angles. (See figure below.)


DEGREES
40
50
30
60
20
70
10
80
0
90
REF ADJ
EXT REF
G

Fill in the blank spaces in the following statement.

The DEGREES dial is used in conjunction with the ________________

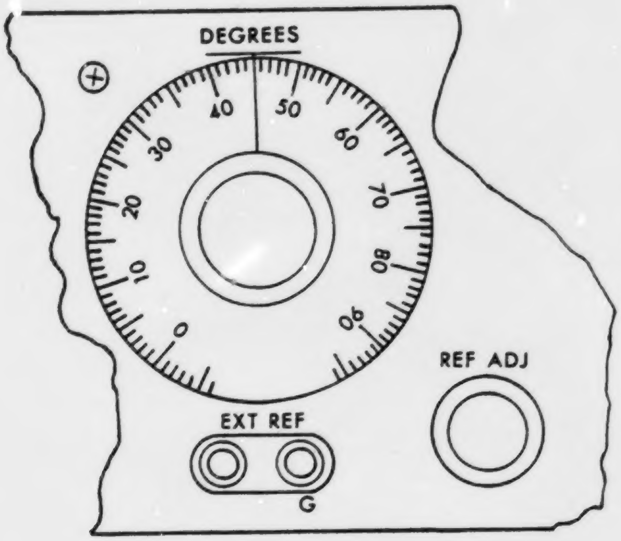
____________________ ____________ for measuring phase angles.

The answer to Frame 11 is: ⓐ

1905.

Frame 13

A reference adjust (REF ADJ knob is located to the lower right of the degrees dial. This knob is used to adjust the meter pointer to a red line at half scale prior to making phase angle measurements. To the left of the REF ADJ knob are the input connectors (EXT REF) for a reference voltage. (See figure below.)



Fill in the blank spaces in the following statements.

1. The reference adjust (REF ADJ) knob is used prior to making ______________ ______________ measurements.

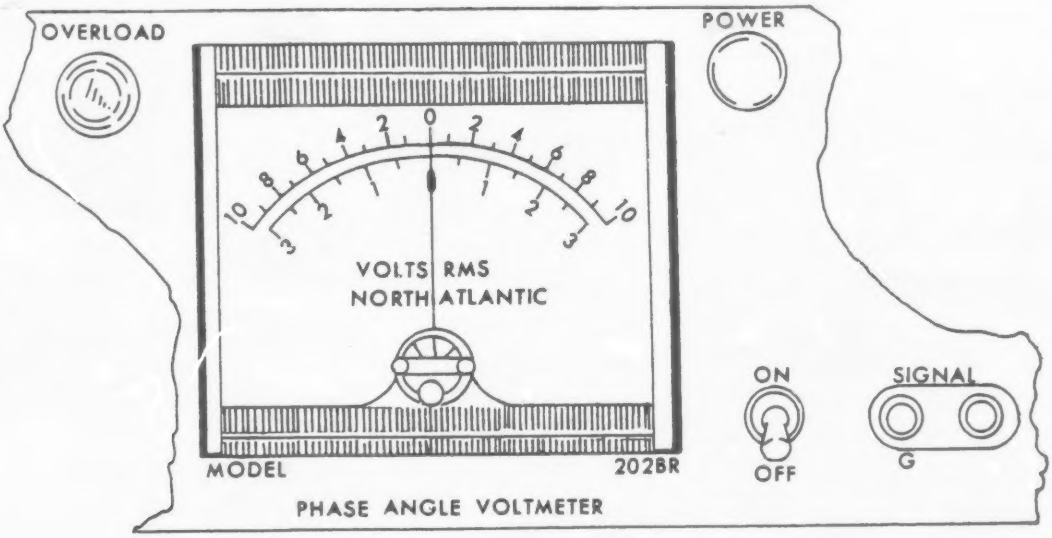
2. The REF ADJ knob is used to adjust the meter pointer to the ______________ ____________________ at half scale.

3. The EXT REF input connectors are for a ______________ voltage.

The answer to Frame 12 is: FUNCTION selector switch

Frame 14

The lamp marked "OVERLOAD" warns of impending amplifier overload. The lamp lights whenever the signal exceeds a prescribed level. The PHASE ANGLE VOLTMETER in the center has two scales, 0 to 3 and 0 to 10. The lower scale (0 to 3) is used whenever the range is a multiple of 3. The upper scale (0 to 10) is used when the range is a multiple of 10. This will be covered in more detail in later frames. Notice the location of these two parts in the figure below.


OVERLOAD
POWER
10 8 6 4 2 0 2 4 6 8 10
3 2 1 0 1 2 3
VOLTS RMS
NORTH ATLANTIC
MODEL
202BR
PHASE ANGLE VOLTMETER
ON
OFF
SIGNAL
G

Circle the letter of the correct answer.

The graduations of the scales on the meter are

a. 0 - 5 and 0 - 10.

b. 0 - 3 and 0 - 30.

c. 0 - 7.5 and 0 - 10.

d. 0 - 3 and 0 - 10.

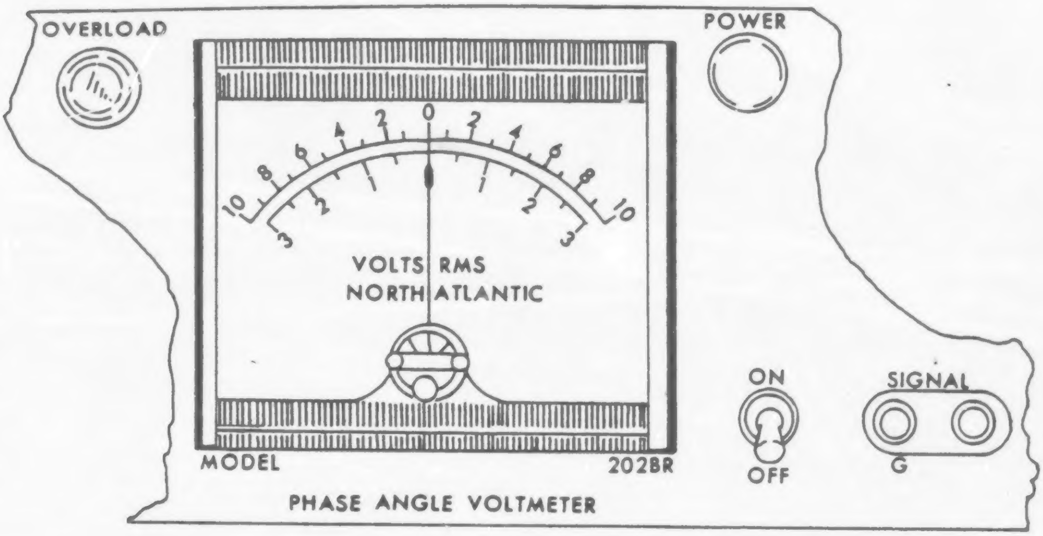
The answers to Frame 13 are:

1. phase angle 2. red line 3. reference

1907..

Frame 15

To the right of the voltmeter is the POWER lamp. The ON-OFF switch is the power switch. When power is applied to the phase angle voltmeter the POWER lamp will light. The SIGNAL input to the right of the power ON-OFF switch is used to make connections for voltage readings. This is the input used for standard VTVM measurements. (See figure below.)


OVERLOAD
POWER
VOLTS RMS
NORTH ATLANTIC
MODEL
202BR
ON
OFF
SIGNAL
G
PHASE ANGLE VOLTMETER

Circle the letter of the correct answer below.

1. Standard VTVM measurements are made with the leads connected to the

   a. EXT REF input.

   b. SIGNAL input.

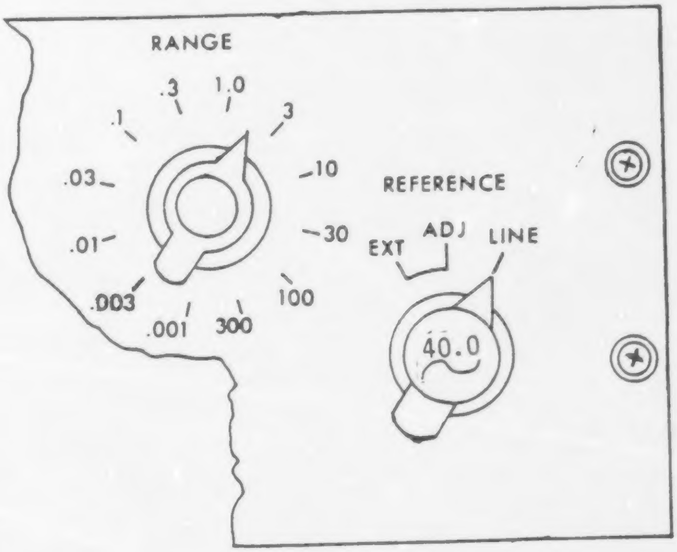
   c. DC signal input.

   d. PHASE ANGLE input.

The answer to Frame 14 is: (d)

Frame 16

The REFERENCE selector selects external (EXT) or LINE reference voltages. This is used as a reference for making phase angle measurements. When using external references, connect the leads to the EXT REF input. The ADJ position and the REF ADJ knob are used to set the meter at the red line at half scale. (See figure below.)


RANGE
.1
.3
1.0
3
.03
10
.01
30
.003
.001
300
100
REFERENCE
EXT
ADJ
LINE
40.0

In the spaces provided write the three positions of the reference selector knob.

1. ______________________________

2. ______________________________

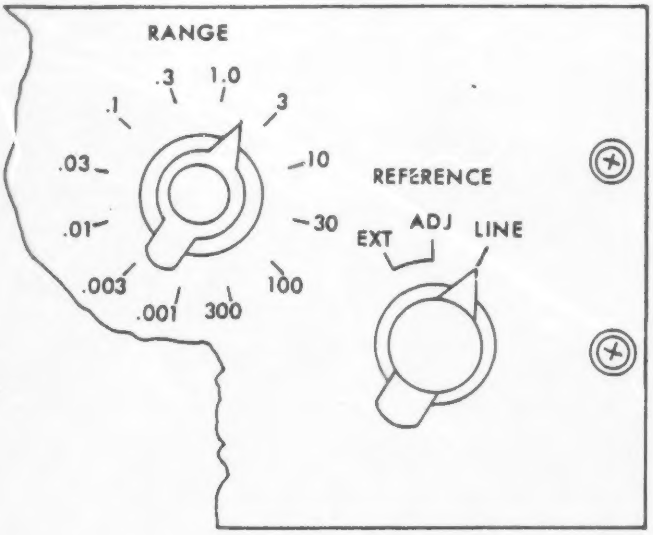
3. ______________________________

The answer to Frame 15 is: (b)

1907

Frame 17

The RANGE selector selects full scale value of the meter. It works in the same manner as the range selector on the PSM/6. The RANGE selector should be set at a value that is known to be greater than the voltage being measured, then reduced after voltage is applied. (See figure below.)



Cross out the incorrect word.

1. The RANGE selector should be set to a value that is known to be (greater, less) than the voltage to be measured.

2. The RANGE selector can be reduced (before, after) voltage is applied.

The answers to Frame 16 are: 1. EXT 2. ADJ 3. LINE

2003

Frame 18

Match the controls on the left to their function on the right by placing the letter corresponding to the function in the blank preceding the control.

CONTROLS

_____1. FUNCTION Selector Switch

_____2. DEGREES Dial

_____3. Reference Adjust

_____4. Reference Selector

_____5. RANGE Selector

FUNCTIONS

a. Selects external or line reference voltage.

b. Used in conjunction with the function selector swtich to measure phase angles.

c. Used to adjust the meter to the red line at half scale.

d. Selects full scale value of the meter.

e. Selects phase angle or VTVM functions.

f. Lights when the load exceeds a prescribed level.

The answers to Frame 17 are: 1. greater 2. after

Frame 19

To measure AC voltages accurately with minimum circuit loading, follow the instructions in the following table.

Step 1	Connect the input leads to the SIGNAL input terminals.
Step 2	Set the RANGE selector to its maximum reading.
Step 3	Set the reference selector to the LINE position.
Step 4	Set the FUNCTION selector to either TOTAL or FUND position.
Step 5	Reduce the RANGE selector until the switch is at the lowest setting that will not cause the meter to peg.

Circle the letter of the correct answer.

1. If the meter pegs the problem is

   a. the function selector is in the wrong position.

   b. the input leads are crossed.

   c. the range selector is set too high.

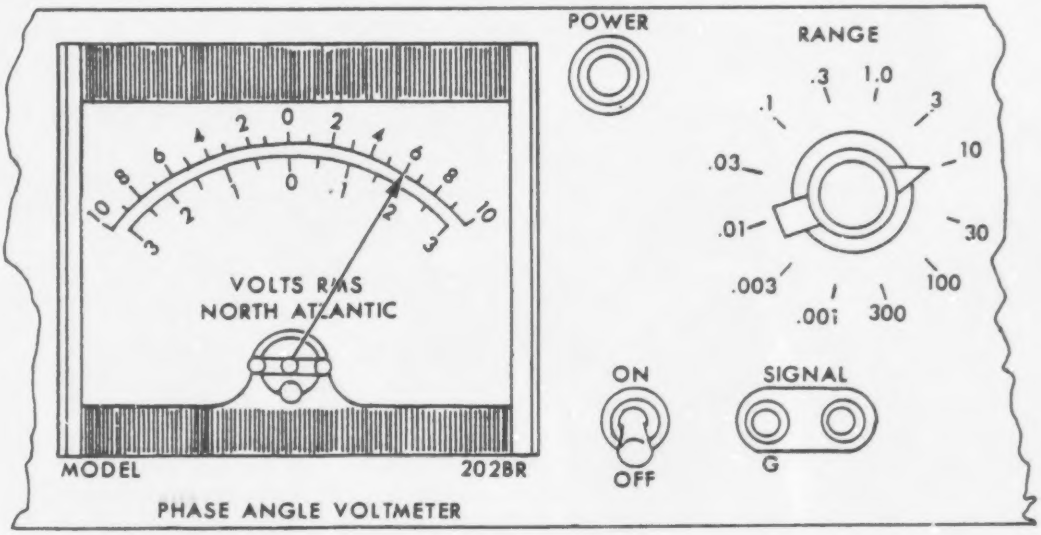
   d. the range selector is set too low.

The answers to Frame 18 are:

__e__1. __b__2. __c__3. __a__4. __d__5.

Frame 20

When the RANGE selector is at its proper setting read the meter in reference to full scale value. (See figure below.) The reading shown in the figure is 6 volts. Full scale value is 10 volts. As previously stated, the full scale value is determined by the position of the RANGE selector switch. If the RANGE selector is in a position that is a multiple of 3, use the lower scale. For voltmeter readings the needle will always be deflected to the right.


POWER
RANGE
.1
.3
1.0
3
10
30
100
300
.001
.003
.01
.03
10 8 6 4 2 0 2 4 6 8 10
3 2 1 0 1 2 3
VOLTS RMS
NORTH ATLANTIC
MODEL
202BR
PHASE ANGLE VOLTMETER
ON
OFF
SIGNAL
G

Circle the letter of the correct answer.

1. If the RANGE switch in figure 15 was in the 1.0 position and the meter indicated as shown, the reading would be

   a. .06 volts.

   b. .6 volts.

   c. 6 volts.

   d. 60 volts.

The answer to Frame 19 is: d

Frame 21

To measure the phase angle between two signals follow the steps in the following table.

1. A voltmeter reading should be taken and the RANGE selector set for maximum safe pointer deflection.
2. Connect the reference signal to the EXT REF input terminals.
3. Set the reference selector to the ADJ position.
4. Use the REF ADJ knob to center the pointer on the red line at half scale right.
5. Return the reference selector to the EXT position.
6. Set the FUNCTION selector to a 0 degree phase angle.
7. Rotate the DEGREES dial until the meter pointer is at zero.
8. Read the amount of phase angle by adding the position of the FUNCTION selector to the reading of the DEGREES dial. This is the phase angle between the signal and the reference voltages.

Fill in the blanks in the following statement.

1. The amount of phase angle is read by adding the position of the ____________________ selector to the reading on the ____________ dial.

The answer to Frame 20 is: ⓑ

Frame 22

Circle the letter of the correct answer.

1. The purpose of the phase angle voltmeter is to measure

    a. frequency and time.

    b. AC current and DC voltage.

    c. the phase angle between two input voltages and DC voltage.

    d. the phase angle between two input voltages and AC voltage.

Match the controls on the left to their function on the right by placing the letter corresponding to the function in the blank preceding the control.

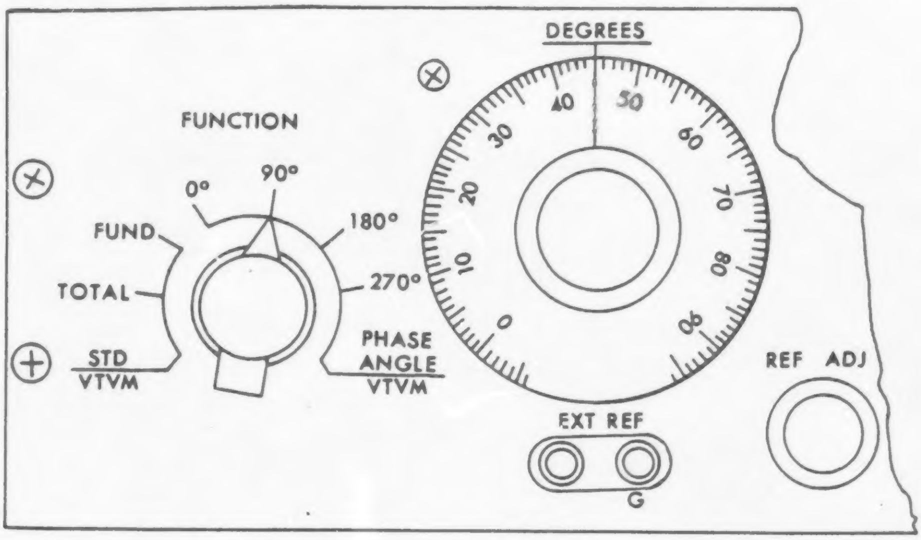
CONTROLS	FUNCTIONS
_____1. FUNCTION Selector Switch	a. Selects external or line reference voltage.
_____2. Reference Adjust Knob	b. Used in conjunction with the function selector switch to measure phase angles.
_____3. Reference Selector	c. Selects phase angle or VTVM functions.
_____4. RANGE Selector	d. Selects full scale value of the meter.
_____5. DEGREES Dial	e. Lights when the load exceeds a prescribed level.
	f. Used to adjust the meter to the red line at half scale.

The answers to Frame 21 are: 1. function, degrees

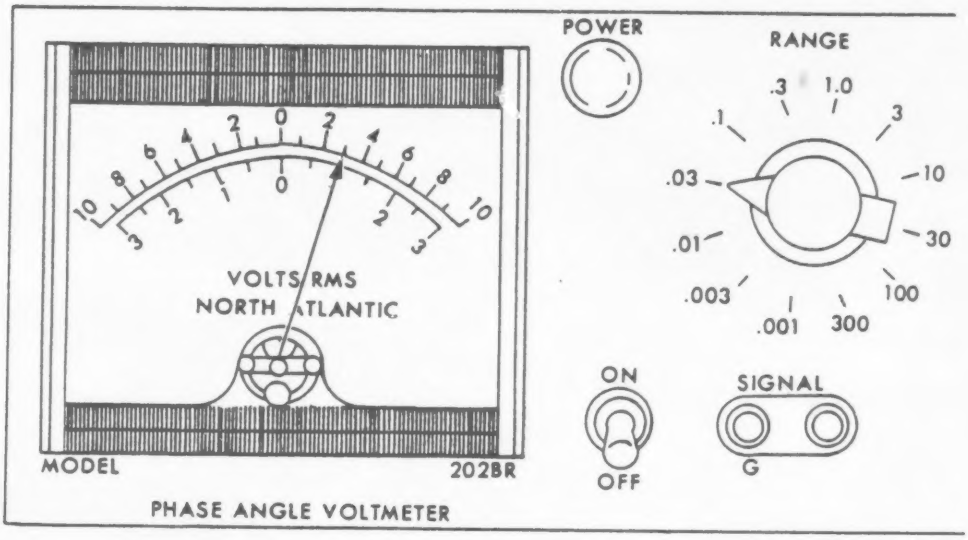
1916

Frame 22 (Cont'd)

Enter the readings of the voltage or phase angles in the spaces provided.


DEGREES
FUNCTION
0°
90°
180°
270°
FUND
TOTAL
STD
VTVM
PHASE
ANGLE
VTVM
0
10
20
30
40
50
60
70
80
90
REF ADJ
EXT REF
G

1. __________________


10
8
6
4
2
0
2
4
6
8
10
3
2
1
0
1
2
3
VOLTS RMS
NORTH ATLANTIC
MODEL
202BR
PHASE ANGLE VOLTMETER
POWER
RANGE
.001
.003
.01
.03
.1
.3
1.0
3
10
30
100
300
ON
OFF
SIGNAL
G

2. __________________

Note: Answers to Frame 22 will be verified by the instructor when you have completed Frame 23.

Circle the letter that identifies the correct answer.

1. The purpose of the DC digital voltmeter is to

   a. replace the PSM/6.
   b. measure and give a digital reading of the DC voltage applied.
   c. measure and give a digital reading of the AC voltage applied.
   d. measure and give a digital readout of the DC current applied.

Match the CONTROL with its FUNCTION by placing the letter of the FUNCTION in the blank to the left of the corresponding CONTROL.

	CONTROL		FUNCTION
_____2.	AUTO Range	a.	Labeled 1, 10, 100, 1000 and AUTO.
_____3.	Calibrate Switch	b.	Provides automatic ranging.
_____4.	Manual Ranges	c.	Selected by depressing the switch for the range desired.
_____5.	POWER Switch	d.	Provides a test reading of 10000.
_____6.	ZERO Adjustment	e.	"Freezes" the last reading of the meter until switched back to the ON position.
		f.	Used with the AUTO range to adjust the display to 00000.

Enter the readings displayed to the right of the drawings.

7. + 001.00 ____________________ DC.

8. - 090.00 ____________________ DC.

Note: The answers to Frames 22 and 23 are located at the bottom of the next page. If you have missed any questions, return to the appropriate frame to insure a complete knowledge of the material.

1917

Section II
ELECTRONIC COUNTER

Frame 24

The Electronic Counter (see figure on the following page) is actually an electronic stop watch. The purpose of the counter is to measure frequency, period and time interval. An input voltage is used to turn the timing circuits on and off. By measuring the time between turning them on and turning them off, accurate readings of the elapsed time can be taken. This method allows the counter to accurately measure time as small as microseconds (one millionth of a second).

Fill in the blanks.

1. The purpose of the Electronic Counter is to measure

____________________, ____________________, and

____________________.

2. The input voltage is used to turn the ______________

______________ ON and OFF.

Answers to Frame 22:

1. a. b. c. [✓ d.] 1. c 2. f 3. a 4. d 5. b

1. 135° 2. 0.01V AC

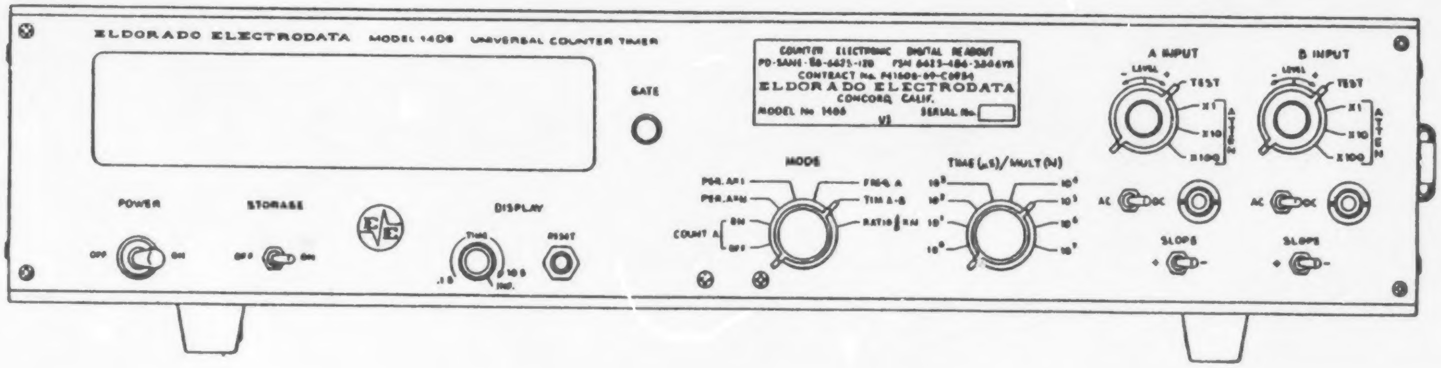
Answers to Frame 23:

1. a. [✓ b.] c. d.

2. b 3. d 4. c 5. e 6. f

7. 1V DC 8. -90V DC

2011


ELDORADO ELECTRODATA MODEL 1406 UNIVERSAL COUNTER TIMER
GATE
COUNTER ELECTRONIC DIGITAL READOUT
PD-SANE-B0-6625-120 FSN 6625-486-3306YA
CONTRACT No. F41608-69-C0984
ELDORADO ELECTRODATA
CONCORD, CALIF.
MODEL No 1406
SERIAL No.
A INPUT
B INPUT
LEVEL
TEST
X1
X10
X100
ATTEN
POWER
OFF
ON
STORAGE
OFF
ON
DISPLAY
TIME
.10
10 S
INF.
RESET
MODE
PER. AP1
PER. APN
COUNT A
ON
OFF
FREQ. A
TIM A-B
RATIO B/A N
TIME (μS)/MULT (N)
10^3
10^2
10^1
10^0
10^4
10^5
10^6
10^7
AC
DC
SLOPE
+
-

2012

2013

1919

The frequencies inside the counter must be very accurate so precise readings may be taken. The frequencies are kept stable by using a crystal mounted in an oven as a frequency standard. The oven keeps the temperature stable and this helps the crystal keep the frequency stable. The counter requires a warmup period of 30 minutes. It is necessary only to plug the counter in for the warmup period--it doesn't need to be turned on.

Circle the letter of the correct answer.

1. The counter should be given a warmup period of

   a. 5 minutes.

   b. 10 minutes.

   c. 30 minutes.

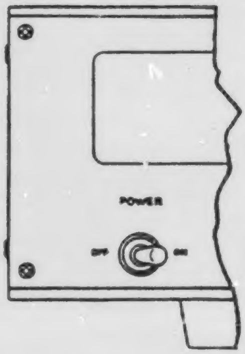
   d. 60 minutes.

The answer to Frame 24 is: 1. frequency, period and time interval.

2. timing circuits.

Frame 26

The Power ON - OFF Switch is located on the extreme lower left of the counter. (See figure below.) The power ON - OFF switch supplies power directly to all circuits except the crystal oven, which is connected directly to the power cord. Anytime power is applied to the power cord the crystal oven is operating. It is necessary only to plug the counter in for the 30-minute warmup period. The power switch may remain OFF and save wear on the switches, timing circuits and other parts inside the counter.



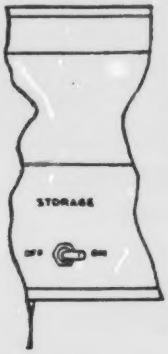
Cross out the incorrect words in the ( ).

1. The crystal oven (does, doesn't) receive power through the power ON - OFF switch.

2. During the warmup period the power switch (is, isn't) required to be ON.

The answer to Frame 25 is: 1. a b [✓ c] d

The Storage Switch is a two-position switch located to the right of the power switch. In the ON position it is used to "store" the count, then display it when the counting is completed. The display remains blank while the count is stored. In the OFf position the display follows the counting from start to stop. (See figure below and note location.)



Fill in the blanks.

1. The storage switch has ________________ positions.

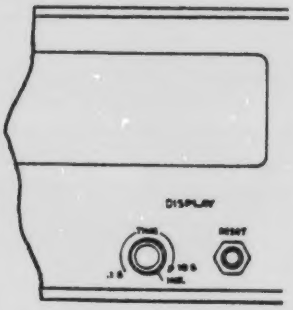
2. If the storage switch is ON, the count is stored until the counting is _______________________.

3. In the OFF position the display ____________________ the counting from start to stop.

The answer to Frame 26 is: 1. doesn't 2. isn't

Frame 28

The Display Time Control is a potentiometer and switch combination. It provides a means for setting the time the count is displayed before it is automatically reset to zero. The time may be varied from 0.1 second to 10 seconds. In the extreme clockwise position, there is a switch contact that is used for an infinite display time setting. In this position the display remains until the reset button to the right is pressed. The reset button is the provision for manually resetting the counter to zero. (See figure below to locate the display time control and reset button.)



Place a (✓) in front of the true statements below.

_____1. The reset button provides a means of manually resetting the counter to zero position.

_____2. A switch contact in the display time control potentiometer provides for an infinite setting of the count display.

_____3. The display time control provides a means of setting the time the count is displayed.

The answer to Frame 27 is: 1. two; 2. completed; 3. follows.

1923

Frame 29

The Mode Switch (see figure below) is a seven-position rotary switch located to the right of the Display controls. It is used to determine the function or mode of the electronic counter. Going clockwise from the extreme counterclockwise position, the modes and their functions are as follows:

(1-2) Count A ON - Count A OFF: Count A ON continuously counts inputs until switch is moved to Count A OFF. Count A OFF stops the input and the count remains fixed. In the Count A modes, the count is cumulative and must be manually reset to zero.

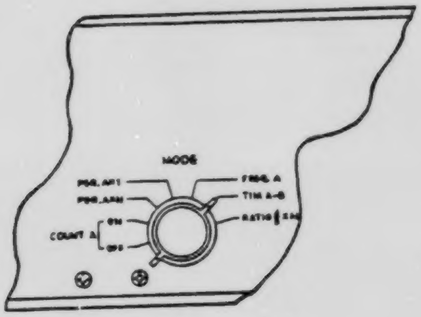
(3) Per A X N: Used for multiple measurement periods. Multiplier (N) switch is used to select the number of periods averaged.

(4) Per A X 1: Measures single period inputs to channel A. (The time the signal starts until it stops is one period.)

(5) Freq A: Performs frequency measurements of input A.

(6) Tim A - B: Times interval measurements between starts on channel A and stops on channel B.

(7) Ratio $\frac{A}{B}$ X N: Provides ratio measurements of channel A to channel B.



Fill in the blanks.

1. The mode or function of the counter is determined by the

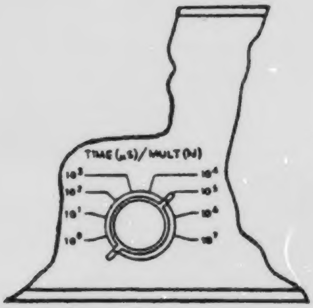
____________ _______________.

The answer to Frame 28 is: (✓) 1. (✓) 2. (✓) 3.

2018

Frame 30

The TIME (µs)/MULT (N) switch is an eight-position rotary switch. It provides the time base or multiplier function for the Mode Switch. It denotes the time in µs, frequency in megahertz, and ratio in numbers using powers of ten. The unit of measure used for the display appears on the right end of the digital display. It is important to remember the unit of measure to accurately read the digital display. (The location of the Time (µs)/MULT(N) switch is shown in figure below.)



Place a (✓) in front of the true statements below.

_____1. The TIME (µs)/MULT(N) switch uses powers of ten.

_____2. The unit of measure used for the display appears on the right end of the digital display.

_____3. The TIME (µs)/MULT(N) switch provides the time base or multiplier function for the mode switch.

The answer to Frame 29 is: 1. mode switch

1925

Frame 31

The A INPUT and B INPUT controls function identically and contain 2 switches. The difference is in the channel they control. (Channel "A" or channel "B".) The table below lists the controls and their function.

1. The Input Connectors are used to connect the external signal to the appropriate channel on the counter.

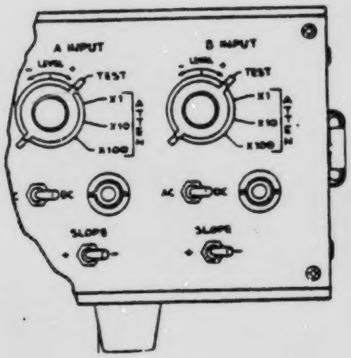
2. The AC/DC Toggle Switch selects input coupling. Use AC for AC signals and DC for DC signals.

3. The + − Slope Toggle Switch selects input slope polarity.

4. The Test/Attenuator Switch provides for self test function, and input attenuation of X1, X10, or X100. (This is the outer switch.)

5. The Trigger Level Control selects + or − trigger point on the input amplifier; it can vary from −1 to +1. (This is the inner sw.)

Refer to figure below for location of the input controls.



Fill in the blanks.

1. The ________________ __________________ are used to connect the external signal to the appropriate channel on the counter.

2. The __________ ___________ ____________ selects input coupling.

3. The ___________________ toggle switch selects input slope polarity.

2020

1926.

4. The ____________ ______________ switch provides for self test, and input attenuation.

5. The ____________ ____________ control selects + or - trigger point on the input amplifier.

The answer to Frame 30 is: (✓) 1. (✓) 2. (✓) 3.

2121

Match the controls on the left to their function on the right by placing the letter of the function in the blank to the left of the control.

_____1. Power Switch

_____2. Storage Switch

_____3. Display Time Control

_____4. Reset Switch

_____5. **Mode Switch**

_____6. Time(μs)MULT(N) Switch

a. Provides time base or multiplier function for the mode switch

b. Provides manual reset

c. Programs counter to a mode of operation

d. **Provides** display storage

e. Provides power to all circuits except crystal oven

f. Provides variable display time from 0 to 10 seconds and an infinite setting

g. Selects input slope polarity

The answer to Frame 31 is: 1. input connectors, 2. AC/DC toggle switch, 3. + - slope, 4. test / attenuation, 5. trigger level

Frame 33

When reading the counter, the entire reading is shown in pictorial display. A decimal point is incorporated in the display. The unit of measure for the display is given at the right end of the display. For time measurements, the unit of measure is one of the following: µs (microseconds), ms (milliseconds) or, s (seconds). For frequency measurements, the unit of measure is one of the following: MHz (megahertz), or kHz (kilohertz). For ratio measurements there is no designation as it is a number (ratio) only.

Identify the symbols by writing the unit of measure that corresponds in the blank to the right.

1. µs ____________________
2. ms ____________________
3. s ____________________
4. MHz ____________________
5. kHz ____________________

The answer to Frame 32 is: e 1; d 2; f 3; b 4; c 5; a 6.

1929

Look at the readings shown and written below the drawings.

ⓐ 0001.20 s ⓑ 0010.00 ms ⓒ 0005.60 MHz

ⓐ 1.2 seconds ⓑ 10 milliseconds ⓒ 5.6 Megahertz

ⓓ 003.10 μs ⓔ 000400 kHz ⓕ 00050.0 MHz

ⓓ 3.1 microseconds ⓔ 400 kilohertz ⓕ 50 Megahertz

Below are 6 displays, enter the readings in the blanks below each.

a 00340.0 s b. 000.500 kHz

a. ____________________ b. ____________________

c. 0095.60 ms d. 00800.0 μs

c. ____________________ d. ____________________

e. 099.000 s f. 873.400 MHz

e. ____________________ f. ____________________

The answer to Frame 33 is:

1. μs microseconds
2. ms milliseconds
3. s seconds
4. MHz Megahertz
5. kHz kilohertz

Frame 35

When using the frequency function, all readings will be displayed as MHz (megahertz) or kHz (kilohertz). Perform the steps given in the following table to measure frequency.

1. Turn the power switch ON.
2. Set the Mode switch to FREQ. A.
3. Set the TIME (µs)/MULT(N) switch to the time base desired.
4. Turn Display Time control full clockwise to infinite setting.
5. Connect input signal to input "A".
6. Pictorial display gives frequency reading with the unit of measure (MHz or kHz).

No Response.

The answer to Frame 34 is: a. 340 seconds; b. 0.5 kilohertz;

c. 95.6 milliseconds; d. 800 microseconds; e. 99 seconds;

f. 873.4 Megahertz

Period measurement uses a single input signal. It routes the signal to the timing circuits, and measures the length of time between the beginning and end of the signal. To perform period measurement with the counter, follow the steps given in the following table.

1. Turn the power switch to the ON position.
2. Turn MODE switch to PER. A X 1.
3. Set TIME (μs)MULT(N) switch for desired resolution; 10^0 - 10^3 for milliseconds, and 10^4 - 10^7 for seconds.
4. Connect the signal to input "A".
5. Set Display Time control to convenient reading rate.
6. Pictorial display shows count, unit of measurement (ms or s) and the decimal point.

Cross out the incorrect word in the ( ).

1. Period measurement is made with the counter in the (A X 1, FREQ. A) mode.
2. The input signal is connected to (input A, input B) connector for period measurement.
3. If during period measurement the TIME (μs)/MULT(N) is set at 10^5, the reading will be in units of (milliseconds, seconds).

Frame 37

Time Interval measurement is very similar to period measurement. The difference is we use two input signals for Time Interval measurement, one to start the count, and another to stop the count. To perform Time Interval measurements, follow the steps given in the following table.

1. Turn power switch ON.
2. Turn MODE switch to TIM A → B.
3. Set TIME (μs)/MULT(N) switch for desired resolution $10^0 - 10^3$ for milliseconds, and $10^4 - 10^0$ for seconds.
4. Connect the start signal cable to input A.
5. Connect the stop input signal to input B.
6. Turn DISPLAY TIME control for a convenient reading rate.
7. Pictorial display shows the time interval counted in the unit of measurement (milliseconds or seconds) and the decimal point.

Place a (✓) in front of the true statements below.

_____1. Both inputs are used for Time Interval measurements.

_____2. The mode switch is set to RATIO $\frac{A}{B}$ X N for time interval measurements.

The answer to Frame 36 is: 1. A X 1; 2. input A; 3. seconds

1933

OSCILLOSCOPE

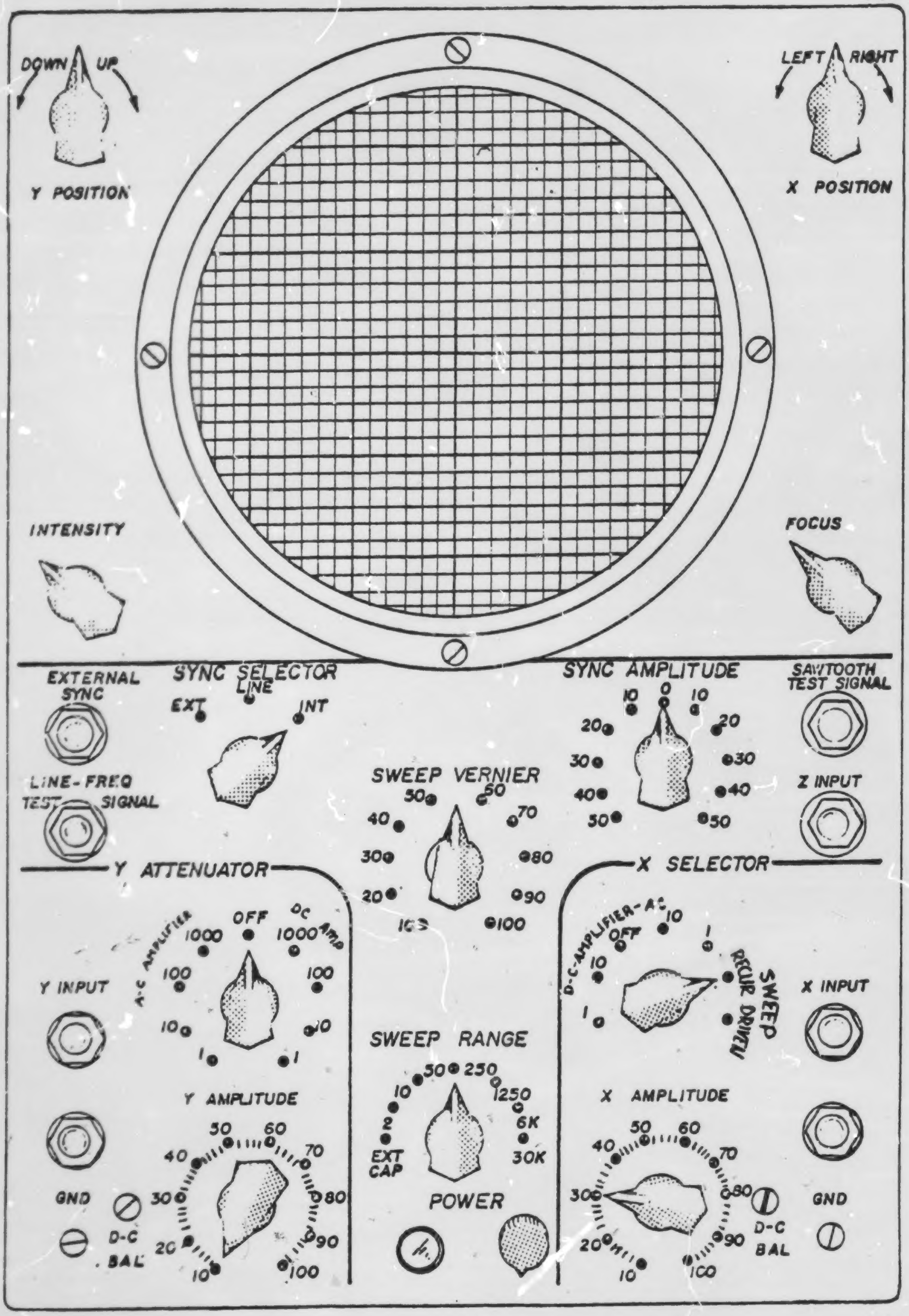
Frame 38

The purpose of the oscilloscope is to view the waveform of a voltage and compare it, if necessary, with the waveform of another. Use the table below and the figure on the next page to review the controls on the oscilloscope.

Y Position Control	Moves the entire trace either up or down.
X Position Control	Moves the entire trace either right or left.
Intensity Control	Varies the brightness of the trace.
Focus Control	Varies focus of the trace.
Sync Selector	Selects either external, internal, or line frequency synchronizing signals.
Sweep Range Control	Varies sweep frequency in gross steps.
Sweep Vernier Control	Varies sweep frequency when used with sweep range control.
Sync Amplitude Control	Selects phase and varies voltage to the synchronizing circuit.
Y Attenuator	Provides for direct peak-to-peak reading of input signal in steps of 1, 10, 100, & 1000.
Y Amplitude Control	Varies amplitude of vertical deflection.
X Selector	Controls horizontal deflection. AMPLIFIER positions selects AC or DC coupling. RECUR provides for continuous sweep. DRIVEN provides for sweep when triggered by sync. sig.
X Amplitude Control	Varies amplitude of horizontal deflection.
Power Rotary Switch	Controls power ON and OFF and varies intensity of the lighted scale on the scope face.

2028

1934


DOWN
UP
Y POSITION
LEFT
RIGHT
X POSITION
INTENSITY
FOCUS
EXTERNAL SYNC
SYNC SELECTOR
EXT
LINE
INT
SYNC AMPLITUDE
10
0
10
20
20
30
30
40
40
50
50
SAWTOOTH TEST SIGNAL
LINE-FREQ TEST SIGNAL
SWEEP VERNIER
50
60
40
70
30
80
20
90
100
100
Z INPUT
Y ATTENUATOR
A-C AMPLIFIER
OFF
DC AMP
1000
1000
100
100
10
10
1
1
X SELECTOR
D-C-AMPLIFIER-AC
OFF
10
1
10
1
SWEEP
RECUR
DRIVEN
Y INPUT
X INPUT
SWEEP RANGE
10
50
250
1250
2
6K
EXT CAP
30K
Y AMPLITUDE
50
60
40
70
30
80
20
90
10
100
X AMPLITUDE
50
60
40
70
30
80
20
90
10
100
POWER
GND
D-C BAL
D-C BAL
GND

1935

Frame 38 (Cont'd)

Circle the letter of the correct answer.

1. The purpose of the oscillosope is to

   a. measure the elapsed time.

   b. provide a digital display of the amplitude gain in the circuit.

   c. provide viewing on 84 channels of UHF.

   d. provide viewing of a voltage waveform, and comparison to another.

The answer to Frame 37 is: (✓) 1; (_) 2.

Frame 39

You will use the oscilloscope most frequently to observe a waveform to locate a source of "noise" or distortion. Connect the ground point of the circuit under test to the Y GROUND terminal on the lower left of the oscilloscope. Connect the test signal to the Y INPUT terminal. Set the SYNC SELECTOR to INT and the X SELECTOR to RECUR. Turn the Y ATTENUATOR control to the position that gives a suitable size trace within the range of the screen. The volts full scale of the control should always be higher than the value of the input voltage. Either AC or DC may be selected by moving the selector to either the right or left.

Note: Do not permit a sharply focused line or spot of high intensity to remain fixed on the screen for any length of time. The screen material may be burned or discolored.

Place a (✓) in front of the true statements below.

_____1. A sharply focused object of high intensity may burn the screen material on the oscilloscope if left for any length of time.

_____2. The volts full scale value should be lower than the value of the input voltage.

_____3. The ground point of the circuit under test should be connected to the Y input connector.

The answer to Frame 38 is: 1. a b c [✓ d]

Frame 40

Increase the SWEEP RANGE control until the trace becomes steady, using the SWEEP VERNIER for fine adjustment of the sweep frequency. When the trace looks like it has almost stopped, "lock it in" using the SYNC AMPLITUDE control. The trace can be locked in with either the positive- or negative-going portion of the signal on the left side, depending on the setting (right or left) of the SYNC AMPLITUDE control. The Y and X amplitude controls may be used to expand the trace in their respective axes for a more detailed view.

Fill in the blanks.

1. When the trace is almost stopped it is locked in using the

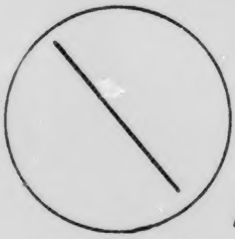
_______________ ____________________ control.

The answer to Frame 39 is (✓) 1. (__) 2. (__)3.

Frame 41

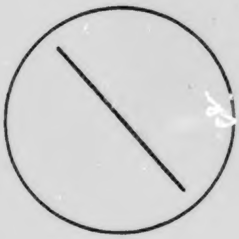
The oscilloscope can be used to determine the difference in phase angle between two signals of equal frequency. Since the exact phase angle will be measured using the Phase Angle Voltmeter, we need only to make approximate readings of the phase shift using the oscilloscope. Begin by connecting one input to the X INPUT terminals and the other to the Y INPUT terminals. Turn on the X and Y Selectors to give a suitable sized trace within the scope face. The trace or pattern will depend upon the degree of phase shift. Note the most commonly obtained patterns and their meanings shown on the next page.

Enter the phase shift in the blank to the right of the drawing.



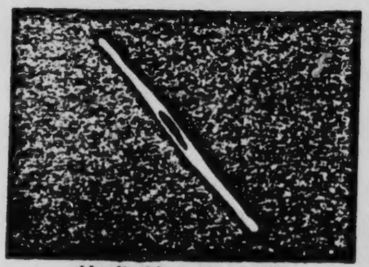
1. ______

The answer to Frame 40 is: 1. Sync Amplitude

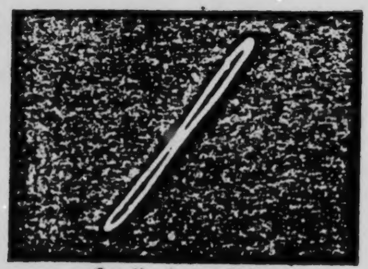


______

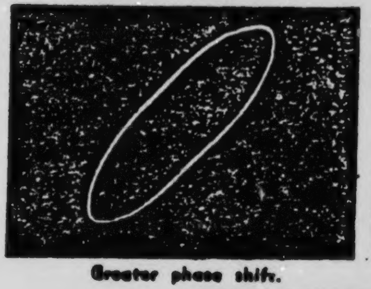
1939.



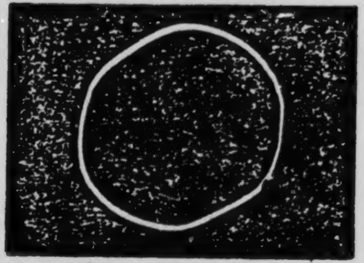
Negligible phase shift.



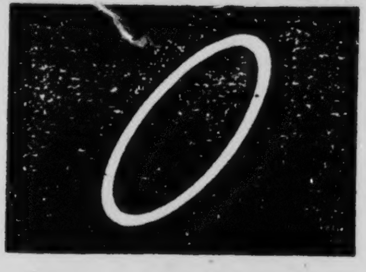
Small phase shift.



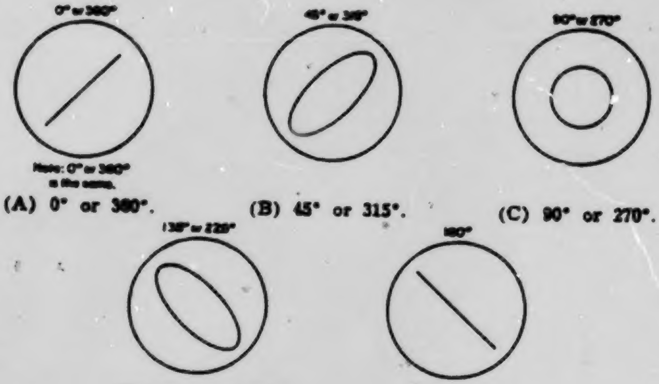
Greater phase shift.



Large phase shift.



Typical phase shift and loss of gain.



(A) 0° or 360°. (B) 45° or 315°. (C) 90° or 270°.

(D) 135° or 225°. (E) 180°.

Waveforms obtained with different degrees of phase shift.

0° or 360°
Note: 0° or 360° is the same.
45° or 315°
90° or 270°
135° or 225°
180°

Frame 42

Circle the letter of the correct answer.

1. The purpose of the Electronic counter is to
   - a. provide a digital readout of frequency, period, and time interval.
   - b. supply a source of power to the crystal oven.
   - c. provide readings of Hertz, Megahertz, and kilohertz only.
   - d. provide a display of the phase relationship between two voltages.
2. The purpose of the Oscilloscope is to
   - a. measure the elapsed time.
   - b. provide a digital display of the amplitude gain in a circuit.
   - c. provide a readout of time intervals.
   - d. provide viewing of a voltage waveform and comparison to another.

Match the functions on the left to the controls on the right by placing the letter of the control in the blank to the left of the corresponding function.

Counter

_____3. provides manual reset.

_____4 programs counter to a mode of operation.

_____5. provides power to all circuits except the crystal oven.

_____6. provides variable display time from 0 to 10 seconds.

a. Display Time Control
b. Reset Button
c. Power Switch
d. Mode Switch
e. Storage Switch

Oscilloscope

_____7. Selects phase and varies voltage to the synchronizing circuits.

_____8. Varies focus of the trace.

_____9. Varies brightness of the trace.

____10. Varies amplitude of vertical deflection.

a. Sync Amplitude Control
b. Y Amplitude Control
c. Intensity Control
d. Focus Control
e. Power Rotary Switch

Enter the readings displayed to the right of the drawings.

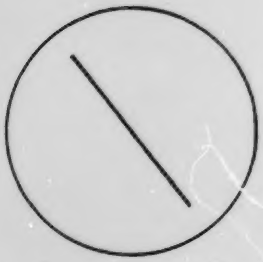
00790.0 ms 11. ____________

0502.30 MHz 12. ____________

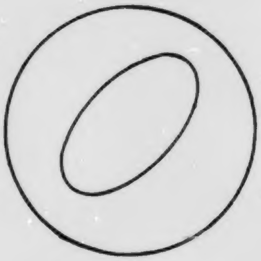
00800.0 μs 13. ____________

348.000 s 14. ____________

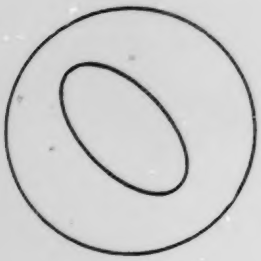
Enter the degrees of phase shift to the right of the drawings.



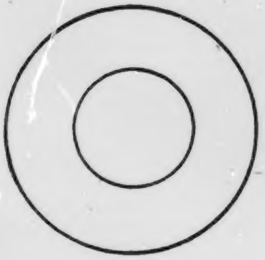
15. ____________



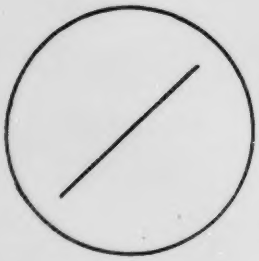
16. ____________



17. ____________



18. ____________



19. ____________

1942

The answer to Frame 41 is: 1. 180 degrees.

The answers to Frame 42 will be verified by the instructor. If you missed any questions, return to the appropriate frame to insure a complete knowledge of the material.

1943

PROGRAMMED TEXT
3ABR32531-PT-501

Technical Training

Avionics Instrument Systems Specialist

FLIGHT DIRECTOR SYSTEM

19 December 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3350 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2038

1944

FOREWORD

This programmed text was prepared for use in course 3ABR32531, Avionics Instrument Systems Specialist. The material contained herein has been validated with 31 students from the subject course. All students achieved the objectives as stated. Average time to complete the text was 278 minutes.

OBJECTIVE

Without references, select statements pertaining to the flight director systems.

INSTRUCTIONS

This programmed text is divided into four (4) sections; Section A, Flight Director System Components; Section B, Horizontal Situation Indicator; Section C, Attitude Director Indicator; and Section D, Modes of Operation. This programmed text presents information in small steps called "frames." Each frame is followed by a form of questioning. After reading each frame, make the required response. Check your answer each time with the correct response being shown at the end of the following frame. If you make an incorrect response, reread the frame before going on to the next frame. If you do not understand the material in this text, raise your hand and your instructor will assist you.

Supersedes 3ABR32531-PT-404, 3ABR32632B-PT-504, 7 July 1977, which may be used until existing stocks are exhausted.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 550; TTVSA - 1

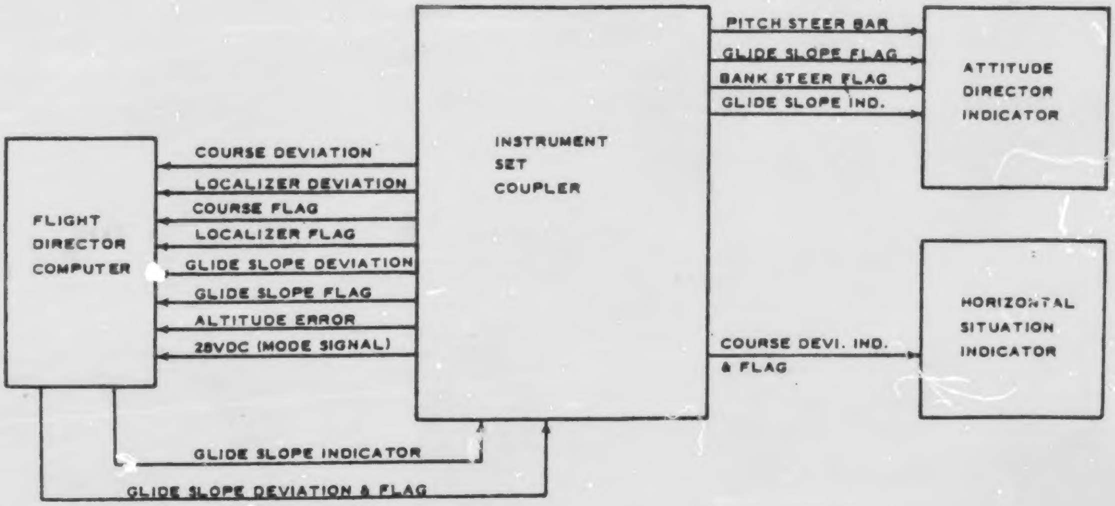
2139

1945

Section A. GENERAL DESCRIPTION OF FLIGHT DIRECTOR SYSTEM COMPONENTS

Frame 1

The Flight Director System (FDS) receives heading, attitude and other information from various systems in the aircraft. This information provides visual pitch, roll, heading, and various types of command information to the aircraft crew members. The two indicators of the Flight Director System that present this information are the Attitude Director Indicator (ADI) and the Horizontal Situation Indicator (HSI). The two other major components of the FDS are the Flight Director Computer (FDC) and the Instrument Set Coupler (ISC). The major components and some signals of the Flight Director Computer System are shown in the block diagram below.


INSTRUMENT SET COUPLER
PITCH STEER BAR
GLIDE SLOPE FLAG
BANK STEER FLAG
GLIDE SLOPE IND.
ATTITUDE DIRECTOR INDICATOR
FLIGHT DIRECTOR COMPUTER
COURSE DEVIATION
LOCALIZER DEVIATION
COURSE FLAG
LOCALIZER FLAG
GLIDE SLOPE DEVIATION
GLIDE SLOPE FLAG
ALTITUDE ERROR
28VDC (MODE SIGNAL)
HORIZONTAL SITUATION INDICATOR
COURSE DEVI. IND. & FLAG
GLIDE SLOPE INDICATOR
GLIDE SLOPE DEVIATION & FLAG

Write the names of the Flight Director System components in the spaces provided.

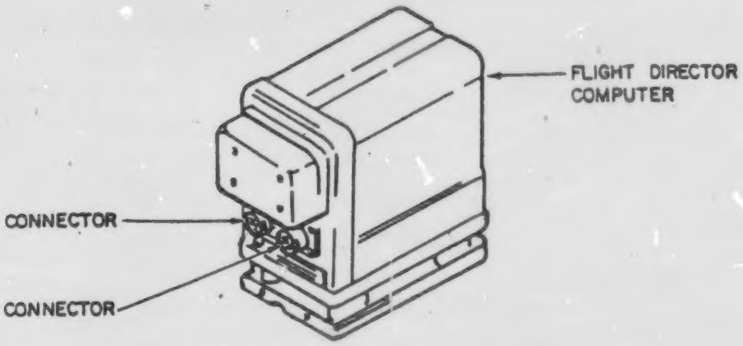
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

2040

1946

Frame 2

The Flight Director Computer (FDC) accepts guidance and sensor information from the Instrument Set Coupler (ISC). In Frame 1 only a portion of the information transferred is shown. The FDC processes this information and transmits it to the indicating sections (bars, pointers, flags, etc.) of the HSI and the ADI. The guidance and sensor information originates in the Navigation and Attack Systems, CADC, AFRS, Glide Slope Radio Receiver, Localizer Radio Receiver, HSI Tacan System, and others. The computer is shown below.



Place a checkmark (✓) in front of each true statement.

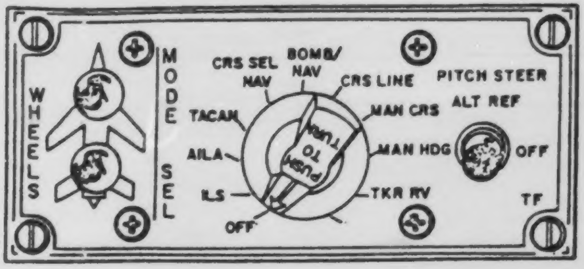
_____1. Signals processed by the FDC are used to operate indicating sections of the ADI and HSI.

_____2. All guidance and sensor information originates in the Flight Director System.

Answers to Frame 1:
1. Flight Director Computer
2. Instrument Set Coupler
3. Horizontal Situation Indicator
4. Attitude Director Indicator

2041

The Instrument Set Coupler (ISC), shown below, is located in the cockpit and is used to select a particular Flight Director System mode of operation. The coupler serves as a conditioning and distribution center for the signals received from the various signal sources in the aircraft. After conditioning the appropriate signals for a particular mode of operation, they are routed to selected Flight Director components and other systems.


WHEELS
MODE SEL
CRS SEL NAV
BOMB/ NAV
CRS LINE
MAN CRS
MAN HDG
TKR RV
TACAN
AILA
ILS
OFF
PUSH TO TURN
PITCH STEER
ALT REF
OFF
TF

Place a checkmark (✓) in front of the true statements.

_____1. The FDC is used for selecting a particular mode of operation.

_____2. After conditioning signals, the ISC transmits its outputs to the Flight Director components.

Answers to Frame 2: _✓_1. _____2.

1948

Frame 4

The Flight Director System contains four panels. These contain the switching circuits required to select the desired mode of operation for a specific flight condition. These panels provide a selection of 10 modes and two submodes of operation. The panels are:

1. Instrument Set Coupler (Control Panel).

2. Miscellaneous Display Panel.

3. Ground Check Panel.

4. Navigation Display Panel.

Place a checkmark (✓) in front of the components that contain switching circuits for the Flight Director System.

_____1. Attitude Director Indicator.

_____2. Flight Director Computer.

_____3. Ground Check Panel.

_____4. Horizontal Situation Indicator.

_____5. Instrument Set Coupler.

_____6. Miscellaneous Display Panel.

_____7. Navigation Display Panel.

Answers to Frame 3: _____1. __✓__2.

2013

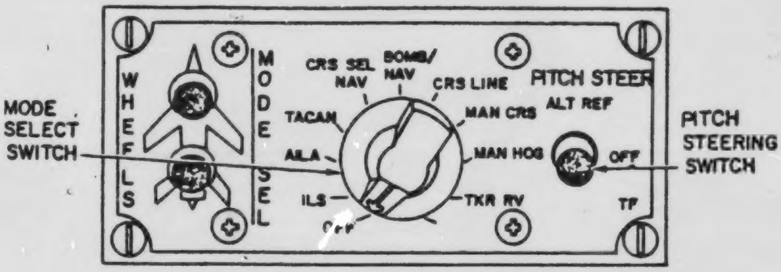
Frame 5

The two switches on the face of the ISC provide the means of selecting the modes of operation. These switches are the:

1. MODE SEL Switch. It provides a selection of 10 different Flight Director modes.

2. Pitch Steer Switch. It determines what signals will be applied to the Pitch Steering Bar on the Attitude Director Indicator.

Refer to the illustration below to become familiar with the two switches and modes of operation. The front panel of the ISC also has two landing gear indicating lamps. These operate independently of the Flight Director circuitry.


MODE SELECT SWITCH
WHEELS
MODE SEL
CRS SEL NAV
BOMB/NAV
CRS LINE
TACAN
MAN CRS
AILA
MAN HDG
ILS
TKR RV
OFF
PITCH STEER
ALT REF
OFF
TF
PITCH STEERING SWITCH

Place a checkmark (✓) in front of the true statements.

_____1. The MODE SEL Switch is used to select a submode of operation.

_____2. The Pitch Steer Bar of the ADI is controlled by the Pitch Steer Switch.

_____3. Landing gear lamps on the ISC are controlled by the FDS.

_____4. Major modes are selected on the MODE SEL Switch.

Answers to Frame 4: _____1. _____2. __✓__3. _____4. __✓__5. __✓__6. __✓__7.

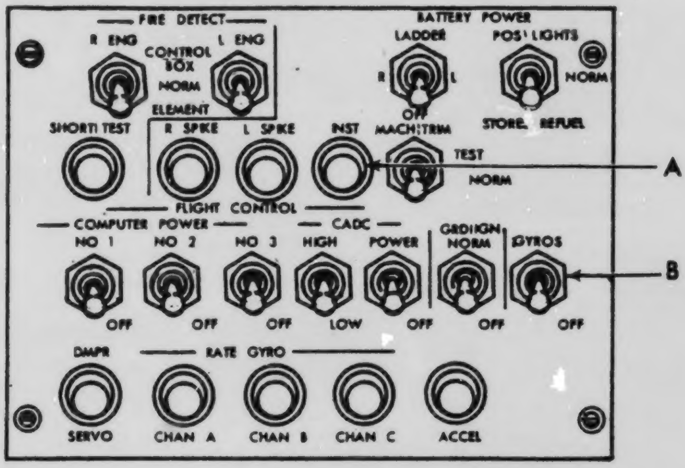
1950

Frame 6

The Ground Check Panel, shown below, contains two switches associated with the Flight Director System. Both switches are used during maintenance operations. They are:

1. INSTR Switch (A).
2. GYROS-OFF Switch (B).

The INSTR Switch is used to perform a self-test of the Instrument Set Coupler. It also performs a self-test of indicators not part of the Flight Director System. The GYRO-OFF Switch is used to remove power from the AFRS, Bearing Distance Heading Indicator (BDHI), and Rate-of-Turn Transmitter when performing maintenance.


FIRE DETECT
R ENG
CONTROL BOX
NORM
ELEMENT
L ENG
BATTERY POWER
LADDER
R
L
OFF
POS' LIGHTS
NORM
STORE. REFUEL
SHORT! TEST
R SPIKE
L SPIKE
INST
MACH TRIM
TEST
NORM
A
FLIGHT CONTROL
COMPUTER POWER
NO 1
NO 2
NO 3
OFF
OFF
OFF
CADC
HIGH
LOW
POWER
OFF
GRD IGN NORM
OFF
GYROS
OFF
B
DMPR
SERVO
RATE GYRO
CHAN A
CHAN B
CHAN C
ACCEL

Place a checkmark (✓) in front of the true statements.

_____1. The INSTR and GYROS-OFF Switches are used to select submodes of operation.

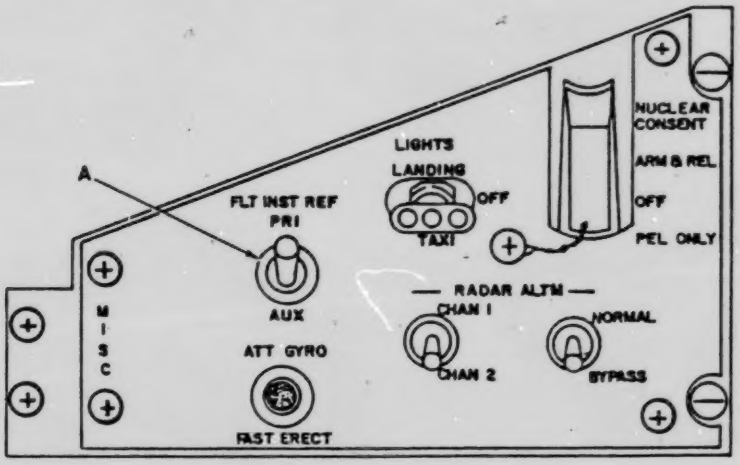
_____2. Self-test of the ISC is performed by using the INSTR Switch.

_____3. The GYROS-OFF Switch controls power to the Flight Director System.

Answers to Frame 5: _____1. __✓__2. _____3. __✓__4.

Frame 7

The Miscellaneous Display Panel contains the FLT INST Ref Switch (Flight Instrument Reference Switch) (A). This switch permits manual selection of either the primary INST or Auxiliary Flight Reference System (AFRS). This is the source of pitch-and-roll signals supplied to the ADI and FDC and the magnetic heading signals supplied to the ADI and HSI. The FLT INST REF Switch operation was covered in the Auxiliary Flight Reference System. The Miscellaneous Display Panel is shown below.


A
FLT INST REF
PRI
AUX
ATT GYRO
FAST ERECT
LIGHTS
LANDING
OFF
TAXI
RADAR ALTM
CHAN 1
CHAN 2
NORMAL
BYPASS
NUCLEAR CONSENT
ARM & REL
OFF
PEL ONLY
MISC

Place a checkmark (✓) in front of the true statements.

_____1. The FLT INST REF Switch determines whether the INS or AFRS supplies signals to the HSI and ADI.

_____2. The FLT INST REF Switch controls the Pitch Steer Bar in the ADI.

Answers to Frame 6: _____1. __✓__2. _____3.

Frame 8

The Navigation Display Panel is not an Instrument System component. This unit is part of the Bombing Navigation System. This system provides command and steering signals to the Flight Director System in particular Flight Director modes.

Place a checkmark (✓) in front of the true statements.

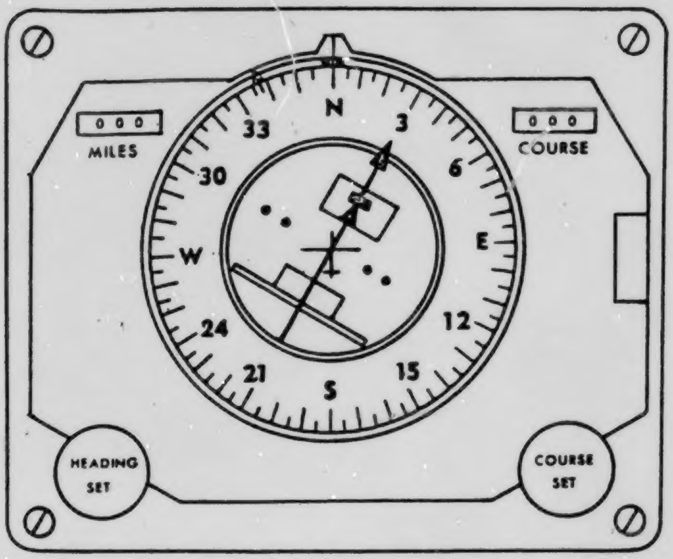
_____1. The Navigation Display Panel is a Flight Director System component.

_____2. The Bombing Navigation System has nothing to do with the Flight Director System.

_____3. Command and steering outputs from the Bomb Navigation System are provided for the Flight Director System.

Answers to Frame 7: __✓__1. _____2.

The Horizontal Situation Indicator (HSI) is the Flight Director System Navigational Instrument. The HSI is located on the main instrument panel and provides the pilot with visual displays of heading, course, distance and bearing information. This multiple display instrument receives the majority of its input signals from the flight director computer. After being processed by the computer, the signals are transmitted to the Instrument Set Coupler and then to the HSI.



Place a checkmark (✓) in front of the true statements.

_____1. The Horizontal Situation Indicator is a Flight Director System Component.

_____2. The HSI provides the pilot with a visual display of aircraft attitude.

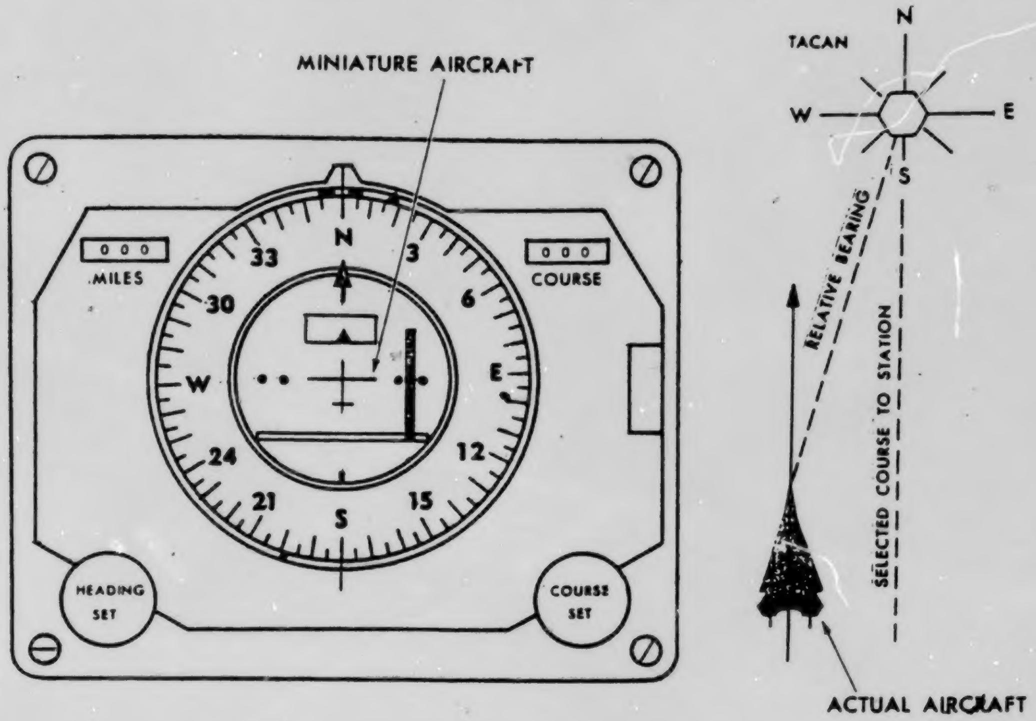
_____3. The majority of the HSI inputs are processed by the Flight Director Computer.

Answers to Frame 8: _____1. _____2. __✓__3.

1954

Frame 10

The indicating sections of the HSI are arranged so that the indicator provides the pilot with a pictorial view of the aircraft's navigational situation. When reading the indicator, the view is as if you are looking at the ground through the indicator. Refer to the illustration below. The miniature aircraft represents the aircraft in which the instrument is mounted. Indications of aircraft heading, course, and bearing are referenced to the minature aircraft.


MINIATURE AIRCRAFT
0 0 0
MILES
0 0 0
COURSE
N
3
6
E
12
15
S
21
24
W
30
33
HEADING SET
COURSE SET
TACAN
N
W
E
S
RELATIVE BEARING
SELECTED COURSE TO STATION
ACTUAL AIRCRAFT

Place a checkmark (✓) in front of the true statements.

_____1. Indications read on the HSI are referenced to the earth's horizon.

_____2. The HSI provides a pictorial view of the aircraft's navigational situation.

_____3. Indications of heading, course, and bearing are referenced to the miniature aircraft symbol.

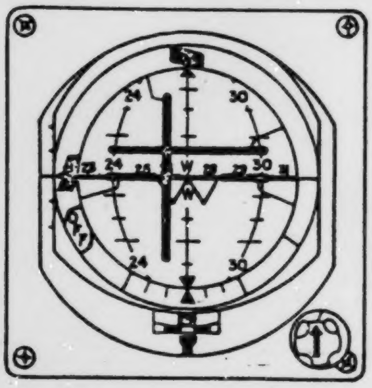
Answers to Frame 9: __✓__1. _____2. __✓__3.

2049

1955

Frame 11

The Attitude Director Indicator located on the main instrument panel is a multiple display indicator which displays attitude, heading, turn and slip, glide slope deviation, and bank and pitch steering information. These indications are provided on an attitude sphere, turn and slip indicator, pitch and bank steering bars, and a glide slope indicator. Flags are also provided to indicate power failure or unreliable signals. The steering bars and glide slope indicator receive input signals from the Flight Director Computer.



Place a checkmark (✓) in front of the true statements

_____1. The Attitude Director Indicator displays attitude, heading, turn and slip, glide slope, and steering information.

_____2. The ADI contains flags for indicating power failure and reliability of input signals.

_____3. The Flight Director System controls most ADI indicating sections.

Answers to Frame 10: _____1. __✓__2. __✓__3.

2050

1956

Answers to Frame 11: ✓ 1. ✓ 2. ✓ 3.

1957

Frame 1

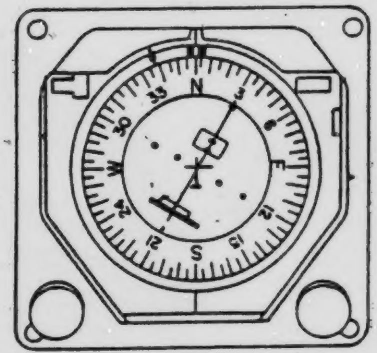
The Horizontal Situation Indicator (HSI) is one of the major components of the Flight Director System. This navigational instrument displays magnetic heading, heading selection, course selection, course deviation, bearing and distance to a selected radio transmitter. This multipurpose indicator provides the pilot with a pictorial view of the aircraft's navigational situation. Indications are provided on eight indicating sections. Warning flags are also provided to indicate power failure and signal reliability.

Place a checkmark (✓) in front of each true statement.

_____1. The HSI is a major component of the FDS.

_____2. The HSI provides the pilot with a pictorial view of the aircraft's attitude.

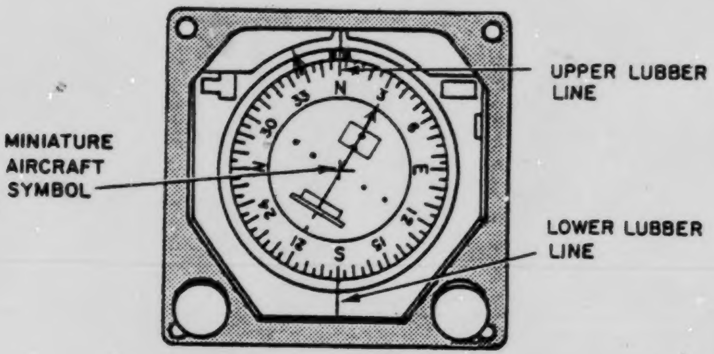
_____3. Signal reliability and power failure are indicated by the HSI.



1958

Frame 2

Look at the illustration below. The upper lubber line indicates the aircraft heading. This heading is read from the compass card. The lower lubber line is used as a reference point. The miniature aircraft symbol represents the actual aircraft. It will always point to the top lubber line.

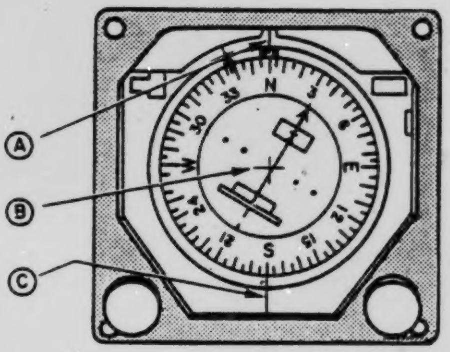

UPPER LUBBER LINE
MINIATURE AIRCRAFT SYMBOL
LOWER LUBBER LINE
N
3
6
E
12
15
S
24
W
30
33

Identify the indicating sections in the illustration below by placing the appropriate letter from the drawing in the proper space in front of the names listed below.

_____1. Miniature Aircraft.

_____2. Top Lubber Line.

_____3. Lower Lubber Line.


Ⓐ
Ⓑ
Ⓒ
N
3
6
E
12
15
S
24
W
30
33

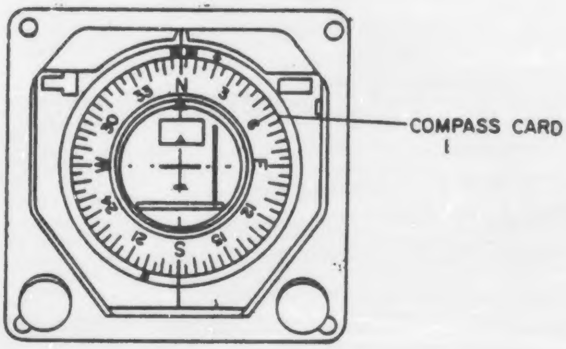
Answers to Frame 1: ✓ 1. _____2. ✓ 3.

2053

Frame 3 1959

Study the Horizontal Situation indicator illustrated below as you read this frame.

The HSI contains four servo-operated indicating sections. The Compass Card is one of these and is shown in the illustration below. The Compass Card (also known as Azimuth Dial) indicates aircraft heading. The heading is marked off to give readings from 0 degrees to 360 degrees. Increments are provided every 5 degrees and numbers every 30 degrees. Letters are also provided at each of the cardinal headings (N, E, S, and W). The Compass Card rotates as the aircraft turns. The aircraft heading is read at the upper lubber line.



Place a checkmark (✓) in front of the true statements.

_____ 1. The Compass Card is a stationary reference for reading aircraft heading.

_____ 2. The Compass Card indicates desired heading.

_____ 3. As the aircraft turns, the Compass Card also turns.

_____ 4. Aircraft heading is read at the bottom lubber line.

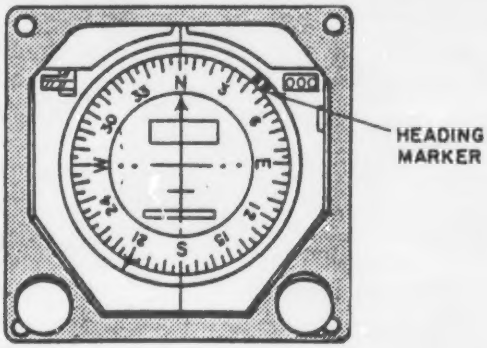
_____ 5. The Compass Card contains reference increments at every five degrees.

Answers to Frame 2: ___ B ___ 1. ___ A ___ 2. ___ C ___ 3.

1960

Frame 4

The Heading Marker is shown in the illustration below. The Heading Set Knob is used to manually set the marker. The Heading Marker can also be servo-operated by a command signal from the Bombing Navigation System. The position of the MODE SEL switch determines which way the Heading Marker operates.



Place a checkmark (✓) in front of the true statements.

_____1. The double rectangular marker on the HSI is the Compass Card.

_____2. The Heading Set Knob is used to manually position the marker against the Compass Card.

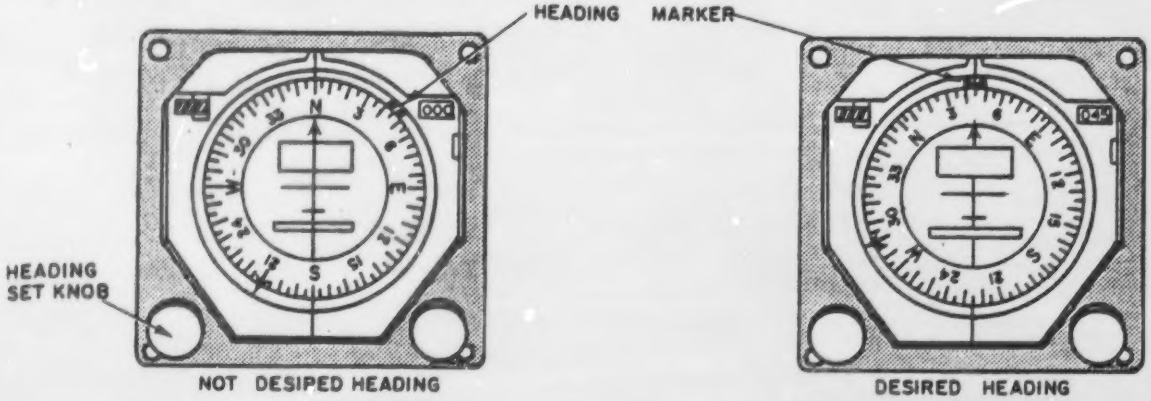
_____3. The Heading Marker can only be positioned against the Compass Card by the Heading Set Knob.

_____4. The MODE SEL switch determines how the marker will be controlled.

Answers to Frame 3: _____1. _____2. __✓__3. _____4. __✓__5.

1961

The Heading Marker can only be manually set when the MODE SEL switch is in the MAN/HDG mode. In this mode the marker serves as a memory device. The pilot uses the Hdg Set Knob to position the marker against the Compass Card. This provides a reference for the direction he desires to fly, and is shown in the illustration below. After the marker has been positioned against the Compass Card, it moves with the Compass Card whenever the aircraft turns. The pilot turns the aircraft until the marker is at the top lubber line. With the Heading Marker at the top lubber line, the pilot is flying his desired heading.



Place a checkmark (✓) in front of the true statements.

_____1. The Heading Marker can be manually set when the MODE SEL switch is in the MAN/HDG mode.

_____2. During aircraft turns, the Heading Marker turns with the Compass Card.

_____3. The aircraft is flying the desired heading when the Heading Marker is at the bottom lubber line.

Answers to Frame 4: _____1. __✓__2. _____3. __✓__4.

1962

Frame 6

The Heading Marker is servo operated in all modes except MAN/HDG. The command input signal is computed by the Bombing Navigation System. This signal drives the heading marker to a command heading on the compass card. Once the Heading Marker is positioned to the computed heading it moves with the Compass Card as the aircraft turns. The pilot flies the aircraft in the direction that moves the Heading Marker to the top lubber line. By steering the aircraft in a direction that keeps the Heading Marker at the top lubber line, the pilot will fly the aircraft to the precomputed destination, target, or rendezvous aircraft.

Place a checkmark (✓) next to the true statements.

_____1. The Heading Marker is servo-operated only in the MAN/HDG mode.

_____2. Computed command heading signals originate in the FDS.

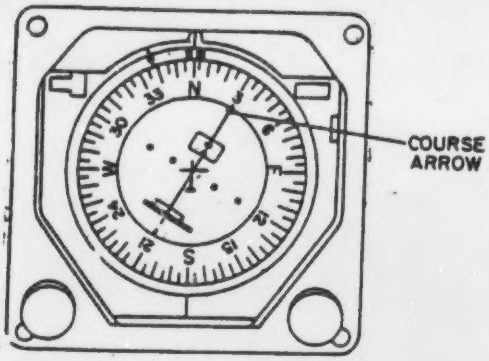
_____3. Steering the aircraft to keep the Heading Marker at the top lubber line, takes the aircraft to a precomputed destination.

Answers to Frame 5: ✓ 1. ✓ 2. _____3.

2057

Frame 7

The Course Arrow is another servodriven indicating section. Like the Heading Marker, the Course Arrow is either servo-operated by signals from the Bomb-Nav System or manually set by the pilot. How the Course Arrow is controlled depends on the position of the MODE SEL switch. The Course Arrow is read against the Compass Card. The Arrow is servodriven or manually set to the desired course on the Compass Card. It then moves with the Compass Card when the aircraft turns. The course arrow is shown in bold lines in the illustration below.



Place a checkmark (✓) next to the true statement/s.

_____1. The Course Arrow can't be manually set.

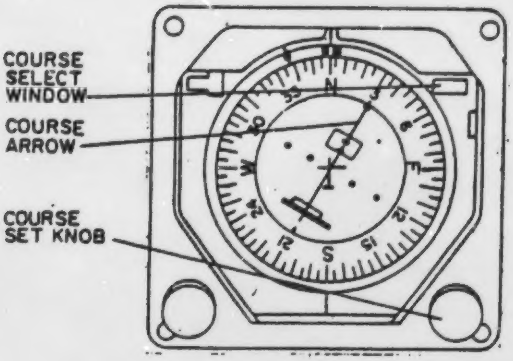
_____2. The Course Arrow is read against the Heading Marker.

_____3. After being positioned against the Compass Card, the Course Arrow moves with the Compass Card during turns.

Answers to Frame 6: _____1. _____2. __✓__3.

1964
Frame 8

A Course Set Knob on the bottom right of the indicator is used to manually position the Course Arrow against the Compass Card. A Course Select Window (course counter) provides a digital readout of the position of the arrow against the Compass Card. This counter is mechanically linked to the Course Arrow and always indicates the same as the arrow. Turning the Course Set Knob controls both the arrow and the counter. Locate the Course Set Knob and the Course Select Window in the illustration below.



Place a checkmark (✓) next to the true statements.

_____1. Turning the Course Set Knob positions both the Course Arrow and Course Select Window.

_____2. The Course Select Window indicates the position of the arrow against the Compass Card.

_____3. The Course Set Knob has no control of the Course Select Window.

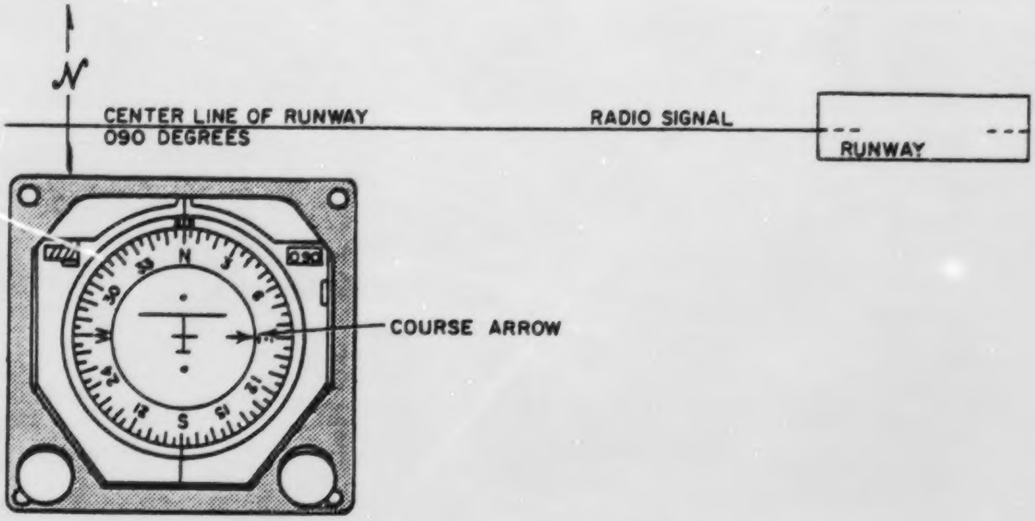
Answers to Frame 7: _____1. _____2. __✓__3.

2059

1965

Frame 9

The Course Arrow is manually positioned during modes of operation that provide radio signals for navigation. An example of this is the radio signal transmitted from the far end of a runway. This signal is used by the pilot to center his aircraft on the centerline of the runway prior to landing. This is shown in the illustration below. Using the Course Set Knob, the pilot sets the runway direction into the Course Select Window. Now the indicator gives the pilot a pictorial view of his navigational situation. The Course Arrow represents the runway. In the illustration below the pilot is flying 000 (N) degrees. This is indicated by the lubber line. The runway direction is 090 degrees and is indicated by the Course Arrow.



Place a checkmark (✓) next to the true statements.

_____1. When landing, a radio signal positions the Course Arrow.

_____2. Runway direction is set into the Course Select Window prior to landing.

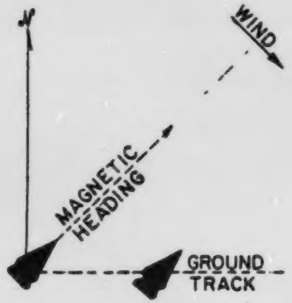
_____3. When landing, the Course Arrow represents the centerline of the runway.

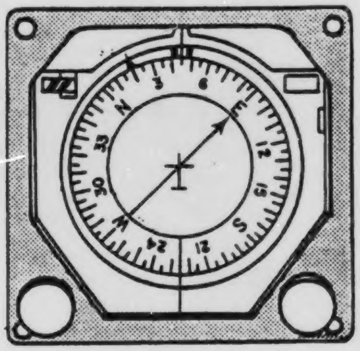
Answers to Frame 8: ✓ 1. ✓ 2. _____3.

1966

Frame 10

During modes of operation that provide command signals to the Course Arrow, it indicates Magnetic Ground Track. Magnetic Ground Track is the direction the aircraft is moving in relation to the ground. In other words if a cross wind pushes the aircraft off course, the pilot must nose the aircraft into the wind to maintain his desired course. With its nose into the wind the aircraft is pointing in one direction but is moving in another. The top lubber line indicates the direction the aircraft is pointing while the Course Arrow indicates the direction the aircraft is moving. In the example in the illustration below the aircraft is pointing in a 45 degree direction but is moving due east over the ground.





Place a checkmark (✓) next to the true statement/s.

_____1. Command signals provide the pilot with indication of Magnetic Ground Track.

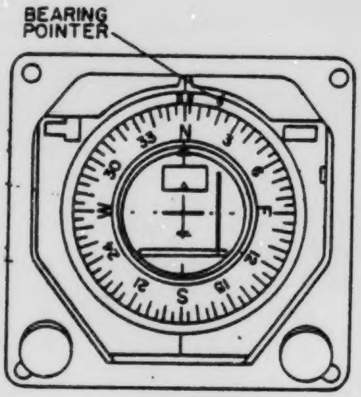
_____2. Magnetic Ground Track is read at the top lubber line.

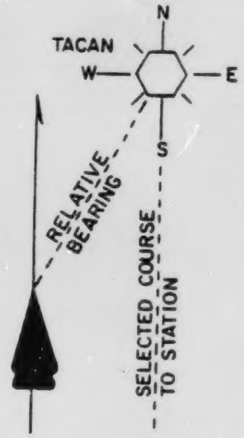
_____3. The pilot must set Magnetic Ground Track into the Course Select Window.

Answers to Frame 9: _____1. _✓_ 2. _✓_ 3.

2 061

The last servooperated indicating section of the HSI to be covered is the Bearing Pointer. This indicator always provides relative bearing to a TACAN radio transmitter. TACAN radio transmitters are located throughout this country. They provide aircraft with radio signals to be used in guiding the aircraft during cross-country flights. Each TACAN station has its own frequency. A pilot sets a TACAN frequency into his radio set. The bearing pointer then indicates where the TACAN station is in relation to his aircraft. This is shown in the illustration below.


BEARING POINTER
N
3
6
E
12
15
S
21
24
W
30
33


N
TACAN
W
E
S
RELATIVE BEARING
SELECTED COURSE TO STATION

Place a checkmark (✓) next to the true statement/s.

_____1. The bearing pointer indicates relative bearing to a radio transmitter.

_____2. Bearing is indicated on the Course Select Window.

_____3. Bearing of a TACAN station must be manually set by the pilot.

Answers to Frame 10: __✓__1. _____2. _____3.

1968

Frame 12

Match the indicating section referencé or control in the figure to the each statement on the left. Place the letter from the illustration in the space provided on the left.

_____1. Bearing Pointer.

_____2. Bottom lubber line.

_____3. Compass Card.

_____4. Course Arrow.

_____5. Course Select Window.

_____6. Course Set Knob.

_____7. Heading Marker.

_____8. Heading Set Knob.

_____9. Miniature aircraft symbol.

_____10. Top lubber line.

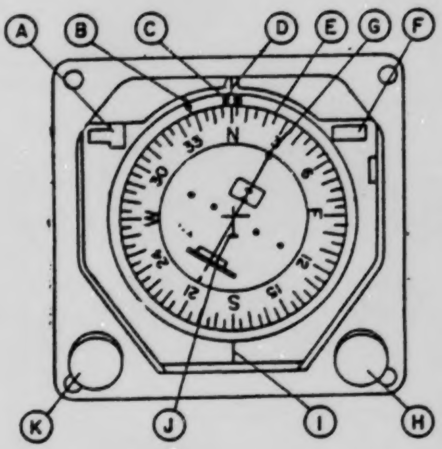
_____11. Set to runway heading.

_____12. Used to manually position heading marker.

_____13. Reference from where magnetic heading is read.

_____14. Provides a digital readout of a selected course.

_____15. Indicates what direction to fly to destination or target.

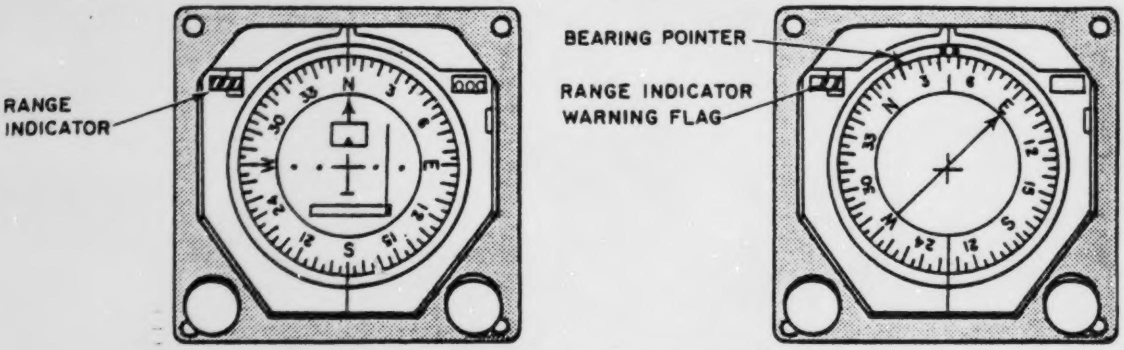


Answers to Frame 11: ✓ 1. _____2. _____3.

2063

Frame 13

The Range Indicator and the Range Indicator Warning Flag are used with the Bearing Pointer. These are shown in the illustration below. The Range Indicator is a digital counter that indicates the distance to or from a selected TACAN radio transmitter. When the pilot sets his radio controls to the frequency of a selected TACAN station, the bearing pointer indicates relative bearing to the station. The Range Indicator at the same time indicates miles to or from the TACAN transmitter. If the range system is not operating or the signal is not reliable, a red and white striped flag drops across the numerals of the Range Indicator.



Place a checkmark (✓) next to the true statements.

_____1. The Range Indicator indicates distance to or from a selected TACAN station.

_____2. Distance is manually set into the Range Indicator.

_____3. The Range Indicator operates in conjunction with the Bearing Pointer.

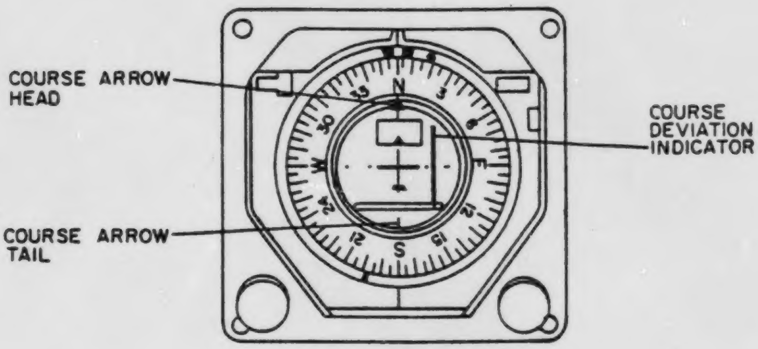
_____4. The Range Indicator Warning Flag indicates reliability of the range signal.

Answers to Frame 12: __B__ 1. __I__ 2. __E__ 3. __G__ 4. __F__ 5. __H__ 6. __C__ 7. __K__ 8. __J__ 9. __D__ 10. __F-G__ 11. __K__ 12. __D__ 13. __F__ 14. __C__ 15.

1970

Frame 14

You may have already noticed that the Course Arrow is a three part indicating section. The Course Arrow head, the Course Arrow tail, and the center position are all part of the Course Arrow. The Course Arrow and Course Deviation Indicator (CDI) are shown below. The CDI rotates with the Course Arrow and also moves to the left or right of the arrow but remains parallel to it.


COURSE ARROW HEAD
COURSE DEVIATION INDICATOR
COURSE ARROW TAIL
N
3
6
E
12
15
S
21
24
W
30
33

Place a checkmark (✓) next to the true statement/s.

_____1. The Course Arrow is a four part indicating section.

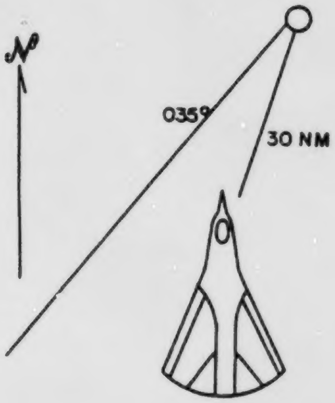
_____2. The CDI rotates in the opposite direction of the Course Arrow.

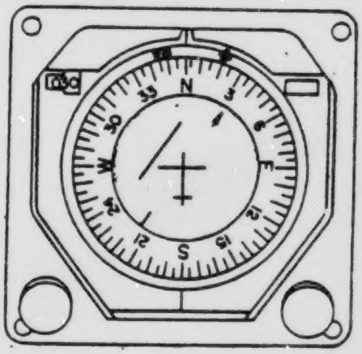
_____3. The CDI moves to the left or right of the Course Arrow.

Answers to Frame 13: __✓__1. _____2. __✓__3. __✓__4.

Frame 15

The Course Deviation Indicator (CDI) indicates the deviation from a preselected course. In the illustration to the right, the selected course is 035 degrees. The aircraft is flying 000 degrees (North). This is indicated on the lubber line. The Course Deviation Indicator is to the left of the Course Arrow. As the aircraft moves near the selected course, the CDI moves toward the Course Arrow. If the aircraft moves beyond the selected course, the CDI will move to the right of the Course Arrow and behind the miniature aircraft symbol.





Using the illustration above, underline the answer that correctly completes the statements.

1. Aircraft magnetic heading is (000, 030, 090, 180) degrees.

2. The selected course is (035, 045, 090, 180) degrees.

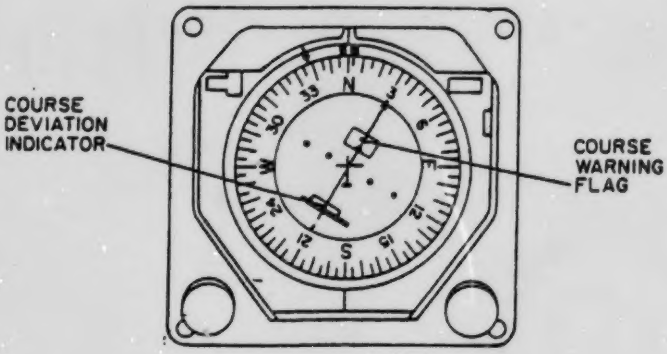
3. The bearing pointer is positioned to (015, 020, 090, 180) degrees.

4. The aircraft is (20, 30, 50, 125) miles from the radio station.

Answers to Frame 14: ____1. ____2. _✓_3.

Frame 16

The Course Warning Flag is also used with the Course Deviation Indicator. This flag is shown in the illustration below. The flag which is red, appears in the window whenever there is an invalid course deviation reading.


COURSE DEVIATION INDICATOR
COURSE WARNING FLAG
N
3
6
E
12
15
S
21
24
W
30
33

Place a checkmark (✓) next to the true statement/s.

_____1. The red flag located below the Course Arrow head indicates an invalid course deviation signal.

_____2. The Course Warning Flag operates in conjunction with the Course Deviation Indicator.

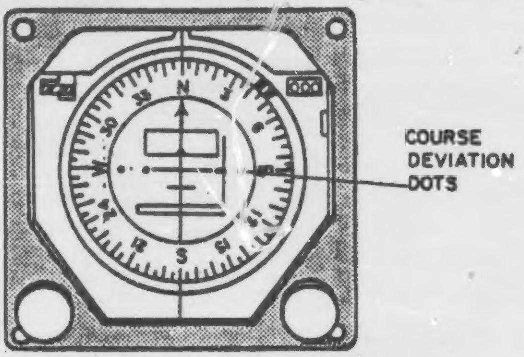
_____3. When the course deviation signal is unreliable, the Range Indicator Warning Flag comes into view.

Answers to Frame 15: 1. 000 2. 035 3. 020 4. 30

1973

Frame 17

Four course deviation dots are provided for reading the amount of course deviation. Two are located to the left of the Course Arrow and two to the right of the Arrow. These dots are shown in the illustration below. Each dot indicates a certain number of degrees of course deviation. The number of degrees depends on the mode of operation selected.



Place a checkmark (✓) next to the true statement/s.

_____1. Course deviation dots are provided for reading relative bearing to a station.

_____2. Course deviation dots are the reference from which deviation from a course is read.

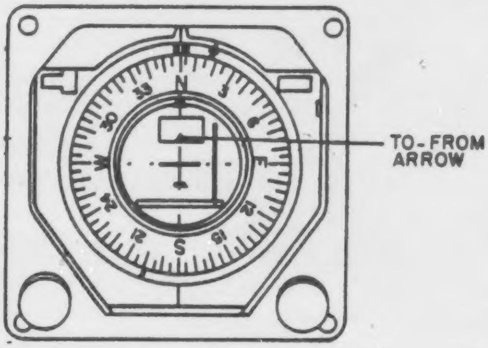
_____3. Each dot represents the same number of degrees of deviation in all modes of operation.

Answers to Frame 16: __✓__1. __✓__2. _____3.

1974

Frame 18

The next indicating section to be discussed is the TO-FROM Arrow. This is shown in the illustration below. This indicating section is used only in the TACAN mode of operation. In all other modes the TO-FROM Arrow is out of view. This section points either to the head or tail of the Course Arrow. When the aircraft is on a course that will take it to the TACAN station, the arrow points to the head of the Course Arrow. When flying away from the TACAN station the TO-FROM Arrow points to the tail of the Course Arrow. In the illustration below the aircraft is flying to the station. The TO-FROM Arrow points to the head of the Course Arrow.



Place a checkmark (✓) next to the true statement/s.

_____1. The TO-FROM Arrow indicates whether the aircraft is flying toward or away from a TACAN station.

_____2. When flying away from a TACAN station the TO-FROM Arrow points to the Course Arrow tail.

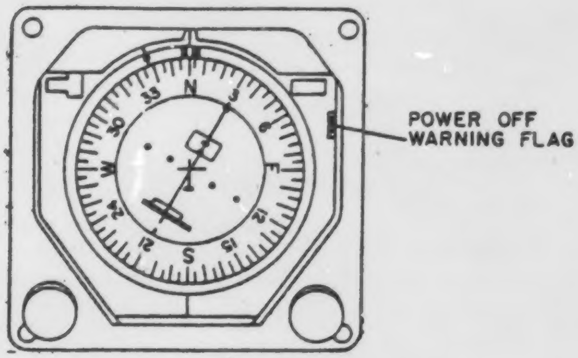
_____3. When not being used, the TO-FROM Arrow remains out of view.

Answers to Frame 17: _____1. __✓__2. _____3.

2069

Frame 19 *1975*

The last indicating section of the HSI to be covered is the Power Off Warning Flag. This is shown in the illustration below. Loss of power to the HSI causes the power Off Warning Flag to come into view.



Place a checkmark (✓) next to the true statement/s.

_____1. The Power Off Warning Flag comes into view with loss of power to the HSI.

_____2. An unreliable course signal causes the Power Off Warning Flag to appear.

Answers to Frame 18: __✓__1. __✓__2. __✓__3.

1976

Answers to Frame 19: ✓ 1. ___ 2.

Note: See HSI film AVA 523B.

2071

Section C. ATTITUDE DIRECTOR INDICATOR

1977

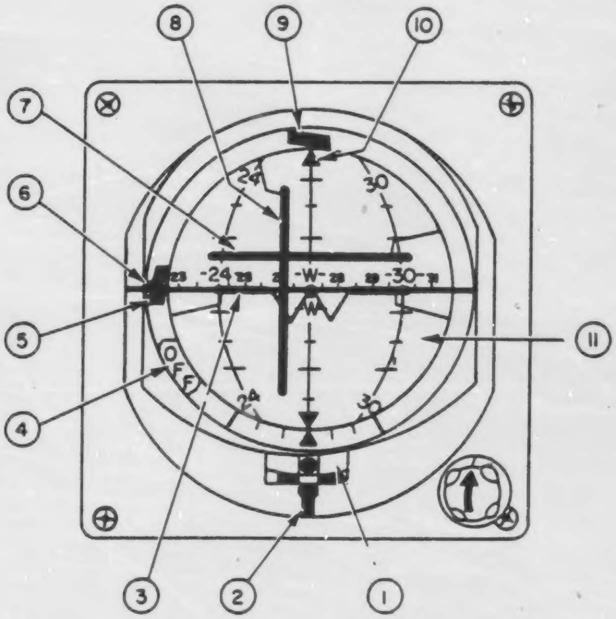
Frame 1

The Attitude Director Indicator is a component of the Flight Director System. This indicator is the pilot's primary attitude instrument. This instrument provides the pilot with visual displays of attitude, heading, turn and slip, glide slope deviation and flight director steering information. Flight director steering information from the Flight Director Computer (FDC) or Instrument Set Coupler (ISC) is applied to the ADI steering pointers and signal reliability warning flags. The mode of operation selected on the Instrument Set Coupler determines what Flight Director signals are being transmitted to the ADI. The mode of operation also determines whether the signals are received from the Flight Director Computer or Instrument Set Coupler.

Below is an illustration of the ADI with the indicating sections numbered. Each indicating section will be covered separately.

NO RESPONSE REQUIRED

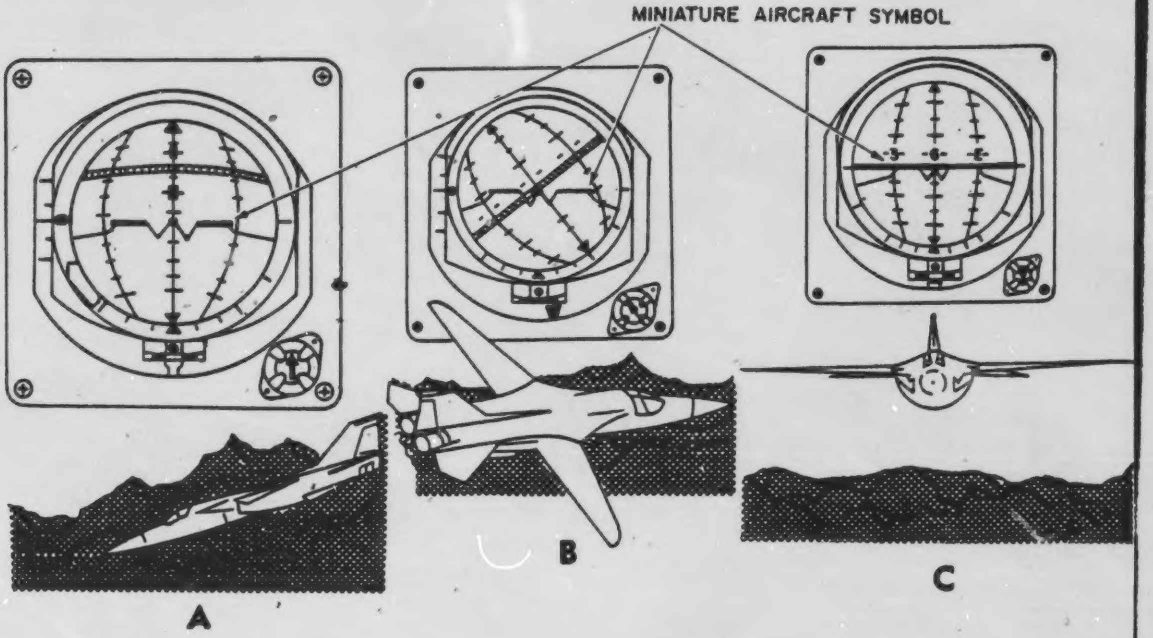
1. Turn and Slip.
2. Rate-Of-Turn Pointer.
3. Minature Aircraft Symbol.
4. Power Warning Flag.
5. Glide Slope Warning Flag.
6. Glide Slope Pointer.
7. Pitch Steering Bar.
8. Bank Steering Bar.
9. Course Warning Flag.
10. Bank Pointer.
11. Attitude Sphere.



1978

Frame 2

The Attitude Sphere displays pitch, roll, and heading. These are read in relation to a fixed miniature aircraft symbol which is 3 in the figure in frame 1. The symbol is shown in the illustration below. The miniature aircraft represents the aircraft while the moveable sphere represents the earth's horizon. Figure A below represents an aircraft with its nose below the horizon. Figure B shows an aircraft with its right wing below the horizon and its left wing above. This is called a right bank. Figure C shows an aircraft flying straight and level with a magnetic heading of 060 degrees.



Place a checkmark (✓) next to each true statement.

_____1. The miniature aircraft symbol represents the earth's horizon.

_____2. The sphere provides visual indications of aircraft pitch, roll, and heading.

_____3. The attitude sphere is movable and is read against the miniature aircraft symbol.

2073

1979

Frame 3

Study each illustration below and place a checkmark (✓) next to the correct flight condition for each illustration.

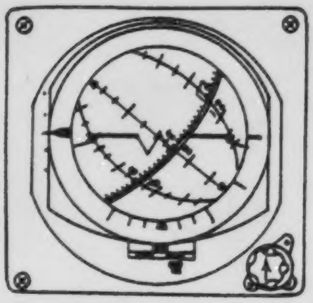


Figure A

_____1. Nose up, right bank.

_____2. Nose up, left bank.

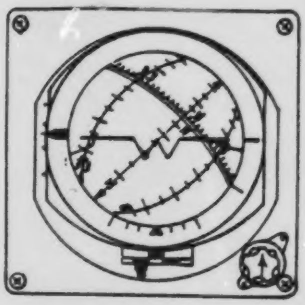


Figure B

_____1. Diving, 090 degree heading.

_____2. Diving, 000 degree heading.

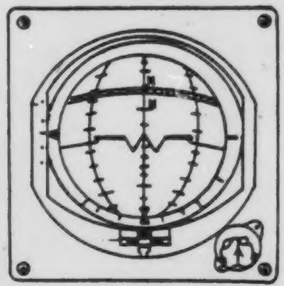


Figure C

_____1. No bank, 000 degree heading.

_____2. No bank, 045 degree heading.

Answers to Frame 2: _____1. __✓__2. __✓__3.

Frame 4

The Bank Steering Bar, item 8 in the figure in frame 1, is a Flight Director indicating section. Input signals to the Bank Steering Bar are received from the Flight Director Computer. The Bank Steering Bar is used by the pilot in making turns and maintaining desired headings and courses. This is a "steer to" indicating section. If the bar deflects to the right, the pilot must steer right.

Place a checkmark (✓) next to each true statement.

_____1. Inputs applied to the Bank Steering Bar are received directly from the Auxiliary Flight Reference System.

_____2. The Bank Steering Bar aids the pilot in maintaining headings and courses.

_____3. When the Bank Steering Bar deflects left, the pilot must steer right.

Answers to Frame 3:

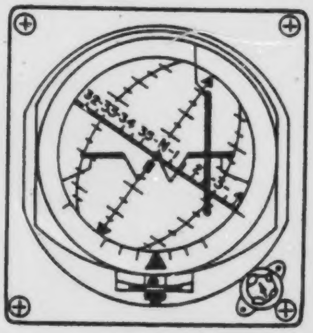
Figure A	Figure B	Figure C
_✓_ 1.	_____ 1.	_✓_ 1.
_____ 2.	_✓_ 2.	_____ 2.

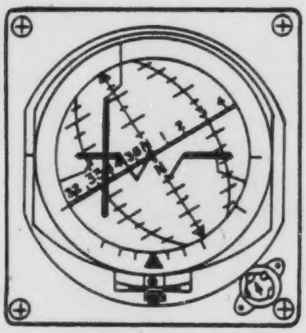
Frame 5

Signals that operate the Bank Steering Bar are:

1. heading error.
2. roll.
3. course error.
4. localizer.
5. TACAN.
6. command steer.

Command signals are from the Bomb Navigation System or Attack Radar. The signal or combination of signals applied to the Steering Bar depends on the position of the MODE SEL Switch. Any time the Bank Steering Bar is in view and being used, roll signals can be applied to it. The other signals to be applied depend on the mode of operation. The illustration below shows the effect of roll (bank) attitudes on the Bank Steering Bar.





Place a checkmark (✓) next to each true statement.

_____1. The Bank Steering Bar can respond to more than one signal at a time.

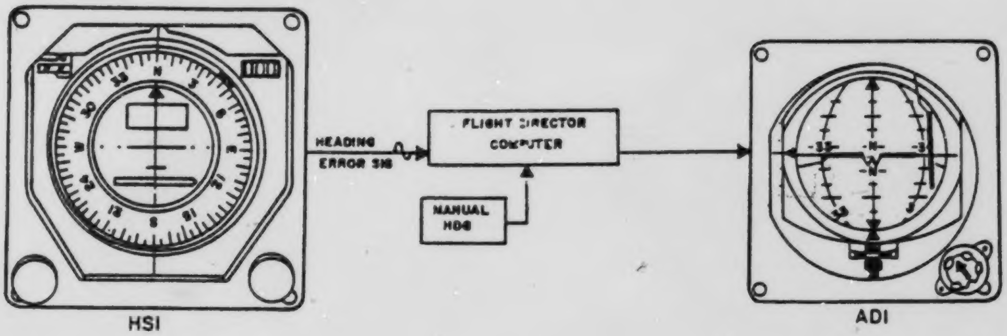
_____2. When the Bank Steering Bar is being used, roll signals operate it.

Answers to Frame 4: _____1. __✓__2. _____3.

1982

Frame 6

Heading error is applied to the Bank Steering Bar in modes when the pilot manually positions the Heading Marker on the HSI. When the HSI Heading Marker is not at the top lubber line, an error signal is produced. This signal is sent to the Flight Director Computer. If the ISC MODE SEL Switch is in the proper position, the heading error signal is sent to the ADI. This causes movement of the Bank Steering Bar.



Place a checkmark (✓) next to each true statement.

_____1. Heading error signals are produced in the Attitude Director Indicator.

_____2. When the HSI Heading Marker is at the lubber line, no heading error exists.

_____3. Heading error signals are transmitted directly from the HSI to the Bank Steering Bar.

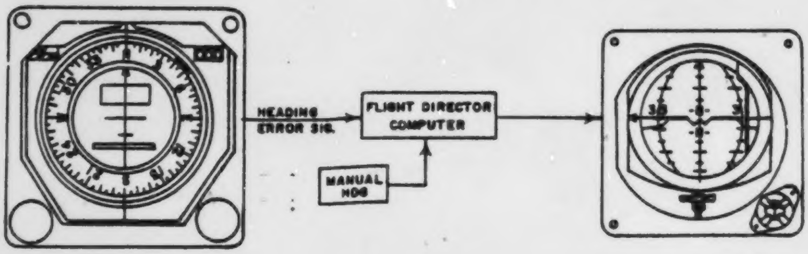
Answers to Frame 5: ✓ 1. ✓ 2.

2077

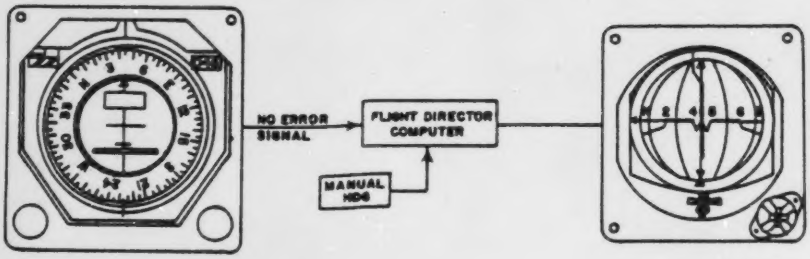
Frame 7

Refer to the illustration below. Figure A shows an HSI with a magnetic heading of 000 degrees. The Heading Marker has been set to a desired heading of 045 degrees. Because the Heading Marker is not at the lubber line, a heading error signal is produced in the HSI. The heading error signal is transmitted to the Flight Director Computer. The MODE SEL Switch on the ISC is positioned to MAN/HDG. This allows the error signal to be sent to the ADI Bank Steering Bar. The Bank Steering Bar is deflected to the right. This tells the pilot to steer right to the desired heading of 045 degrees. Figure B shows that the aircraft has turned to the desired heading and the Heading Marker is now at the lubber line. With the Heading Marker at the lubber line, no heading error exists. This means the ADI Bank Steering Bar is centered.

A


HEADING ERROR SIG.
FLIGHT DIRECTOR COMPUTER
MANUAL HDG

B


NO ERROR SIGNAL
FLIGHT DIRECTOR COMPUTER
MANUAL HDG

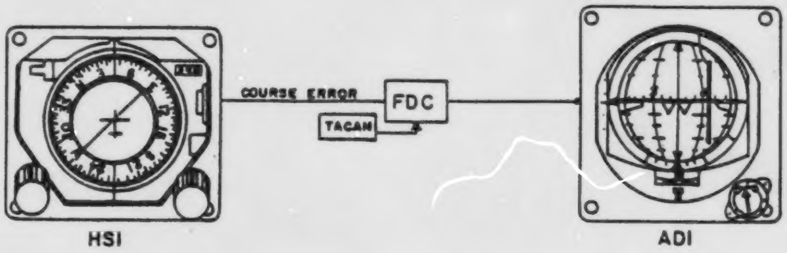
NO RESPONSE REQUIRED

Answers to Frame 6: ____1. __✓__2. ____3.

1984

Frame 8

Course error can also be applied to the Bank Steering Bar. Course error is the signal produced in the HSI when the Course Arrow is not at the top lubber line. Course error signals are sent to the Flight Director Computer. The course error signal is applied to the Bank Steering Bar when the MODE SEL Switch is in the right position. The illustration below shows the Course Arrow displaced away from the lubber line. A course error signal is being transmitted to the Flight Director Computer. In the appropriate mode of operation, the signal is applied to the ADI Steering Bar.



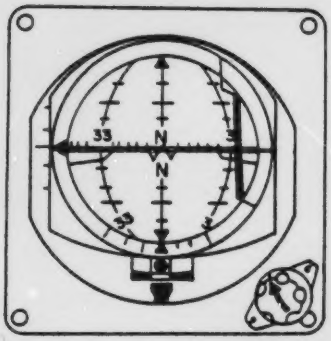
Place a checkmark (✓) next to each true statement.

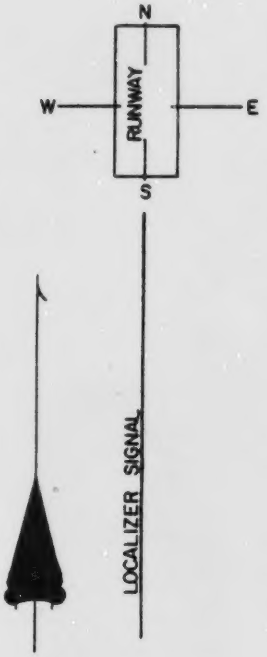
_____1. Course error is produced in the HSI when the heading marker is not at the lubber line.

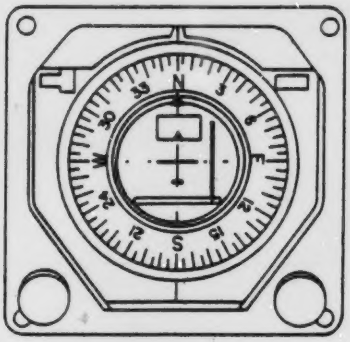
_____2. Course error causes the ADI Bank Steering Bar to deflect.

Frame 9 1985

TACAN or localizer error signals can be applied to the Bank Steering Bar. These signals occur when the aircraft drifts or deviates from a preselected TACAN or localizer course. We refer to these signals as course deviation error signals. In the illustration below, a runway heading is the preselected course. The aircraft has drifted to the left of the course. This is indicated by the HSI Course Deviation Indicator and the ADI Bank Steering Bar deflecting to the right. This tells the pilot a right turn is needed to get back on course.







Place a checkmark (✓) next to each true statement.

____1. Course deviation error signals occur when the aircraft is to the left or right of a preselected TACAN course.

____2. Course deviation error signals occur when the aircraft is to the left or right of a preselected localizer course.

____3. If the aircraft drifts to the left of a course, the Bank Steering Bar deflects to the left.

Answers to Frame 8: ____1. __✓__2.

2 18 43

1986.

Frame 10

The Bank Steering Bar is also controlled by the input signals from the Bomb/Nav and Attack Radar Systems. The position of the MODE SEL Switch determines in what modes command steering signals operate the Steering Bar. In the correct mode, a command signal moves the Course Arrow to the course that the pilot must fly to reach a precomputed target or destination. If the aircraft deviates from the command course, the Bomb-Nav System provides the command steering signal to operate the Bank Steering Bar. The bar indicates the direction to steer. Steering to the bar returns the aircraft to the command course.

Place a checkmark (✓) next to each true statement.

_____1. Only signals produced by the Flight Director System can operate the Bank Steering Bar.

_____2. Deviation from a precomputed course causes movement of the Bank Steering Bar.

_____3. The Bank Steering Bar provides steer-to information to fly back to a command course.

Answers to Frame 9: __✓__1. __✓__2. _____3.

2081

Frame 11

The next indicating section of the ADI to be covered is the Pitch Steering Bar. This bar is shown as item 7 in frame 1. The bar provides horizontal steering reference. Like the Bank Steering Bar, this is a steering to indicating section. If the bar deflects up, the pilot must fly the aircraft up to the bar. This indicating section is also referenced to the miniature aircraft.

Complete the following statements by underlining the correct words to complete the statements.

1. The Pitch Steering Bar provides (vertical, horizontal) steering references.

2. The Pitch Steering Bar is referenced to the (sphere, miniature aircraft).

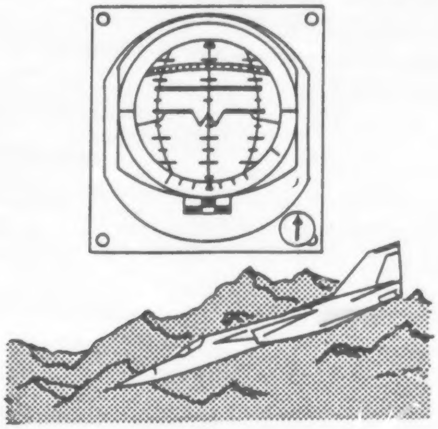
3. If the Pitch Steering Bar deflects up the pilot must fly the aircraft (up, down).

Answers to Frame 10: ____1. __✓__2. __✓__3.

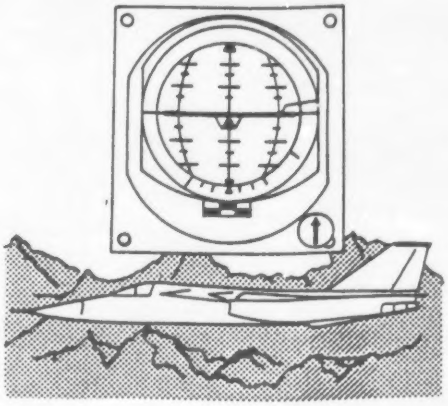
1988

Frame 12

Various signals can be applied to the Pitch Steering Bar. The ISC Pitch Steer Switch and the MODE SEL Switch determine the signal that operates the bar. The illustration below shows the effect of pitch attitudes on the Pitch Steering Bar. Figure A shows an aircraft with a nose down attitude in relation to the horizon. The ADI Pitch Steering Bar is deflected up. This shows the pilot that he must steer the aircraft up to the bar. Figure B shows that the aircraft's nose is up and the Steering Bar is centered, showing that no steering correction is necessary.



A



B

Place a checkmark (✓) next to each true statement.

_____1. Control of the Pitch Steering Bar is determined by the MODE SEL and Pitch Steer Switch positions.

_____2. The Pitch Steering Bar provides the pilot with steer-to information.

Answers to Frame 11: 1. horizontal 2. miniature aircraft

3. up

2093

Frame 13

The Glide Slope Pointer, item 6 in frame 1, is located on the left of the ADI. This indicating section is used as an aid for making an instrument landing. The pointer moves up or down in relation to the miniature aircraft. This represents the glide angle necessary for landing on the near end of the runway.

Place a checkmark (✓) next to each true statement.

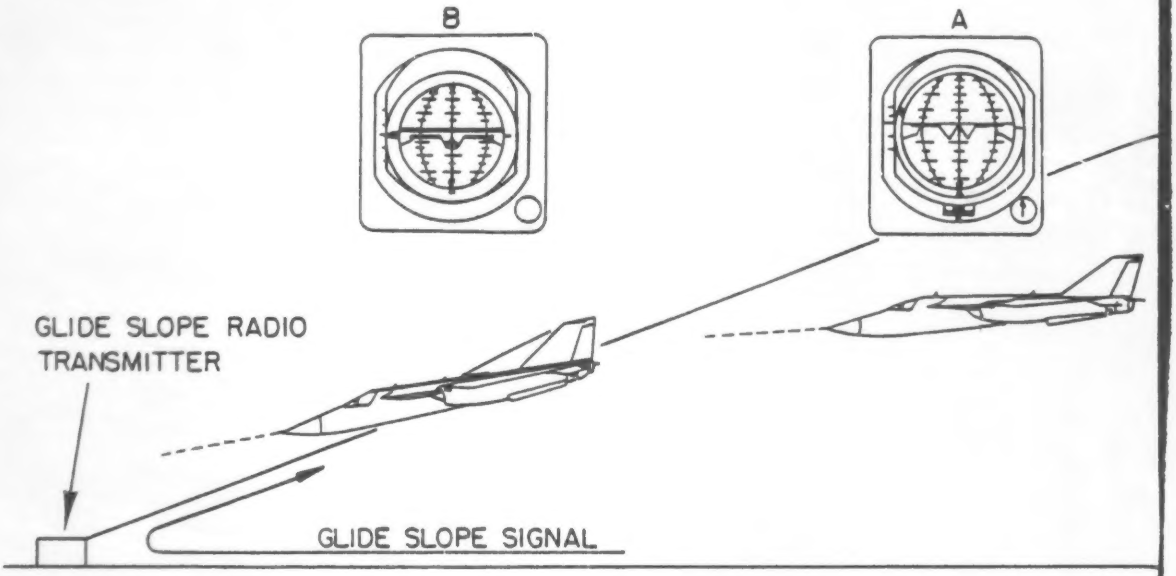
_____1. The Glide Slope Pointer is used in obtaining proper glide angle for landing.

_____2. The Glide Slope pointer represents the earth's horizon.

_____3. The Glide Slope Pointer moves to the left or right of the miniature aircraft.

Answers to Frame 12: __✓__1. __✓__2.

In the illustration below, indicator A shows the aircraft approaching the glide slope. The glide slope signal is transmitted from the near end of the runway. The Glide Slope Pointer is displaced above the miniature aircraft. This shows that the glide slope is above the aircraft. Indicator B shows that the aircraft has reached the glide slope signal. Therefore, the Glide Slope Pointer has moved down to the miniature aircraft. As long as the pilot holds the aircraft on the glide slope the pointer remains centered with the miniature aircraft.



Place a checkmark (✓) next to each true statement.

_____1. Glide slope signals are used for aligning the aircraft to the runway centerline.

_____2. Glide Slope signals are transmitted from the near end of the runway.

_____3. Before the aircraft reaches the glide slope signal, the Glide Slope Pointer is below the miniature aircraft.

Answers to Frame 13: __✓__1. _____2. _____3.

Frame 15

1991

An Inclinometer and Rate-of-Turn Needle, items 1 and 2 in frame 1, at the bottom of the indicator provides turn and slip information. The Inclinometer is the curved tube with the ball in it. The ball indicates aircraft slip, skid, and coordinated turns. The Rate-of-Turn Needle indicates rate of turn (degree of turn per minute). Rate-of-turn signals are provided by a remotely located gyro. Reading this portion of the indicator is the same as reading the conventional Bank and Turn Indicator.

Place a checkmark (✓) in front of each true statement.

_____1. Bank and turn information is read on a separate indicator.

_____2. Rate-of-turn information is received from a remote gyro.

_____3. Coordinated turn is indicated by the Rate-of-Turn Pointer.

Answers to Frame 14: _____1. __✓__2. _____3.

2196

1992

Two warning flags provide reliability information. These flags indicate whether or not the input signals to the ADI have enough strength to operate the Glide Slope and Bank Steering Bar accurately. The third flag is the Attitude Warning Flag, item 4 in frame 1, which comes into view in event of power failure to system components or failure of the ADI. The glide slope warning flag, item 5 in frame 1, is shown on the left and course steering warning flag, item 9 in frame 1, is at the top of the illustration.

Place a checkmark (✓) in front of each true statement.

_____1. Warning flags indicate the reliability of input signals to the Glide Slope Pointer and Bank Steering Bar.

_____2. The Attitude Warning Flag indicates the reliability of input signals to the Pitch Steering Bar.

_____3. The flag marked OFF comes into view with loss of power to the ADI.

Answers to Frame 15: _____1. __✓__2. _____3.

Answers to Frame 16: __✓__1. _____2. __✓__3.

See ADI film AVA 523A.

2497

Section D. MODES OF OPERATION

Frame 1

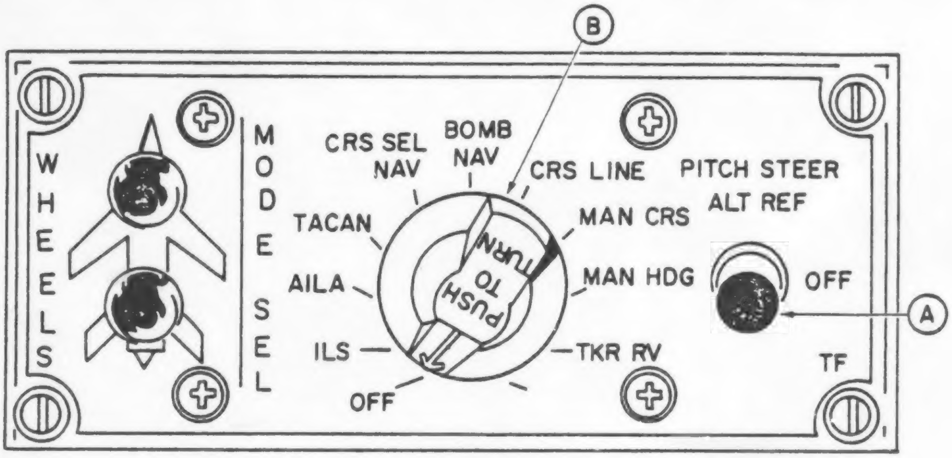
The flight director system (FDS) receives its input signals from the various other aircraft systems. This portion of the text will cover basic signals that are applied to the ADI and HSI in various modes of operation. Because of the similarity between some of the navigation modes, not all modes will be covered in detail. The MODE SEL switch and the PITCH STEER switch on the instrument set coupler determine what signals will be applied to the indicators (ADI & HSI). The operation of each switch and its position will be covered separately. In order to perform operational checks and troubleshooting procedures on the trainer, it is necessary to have a basic understanding of the system operation in various modes.

NO RESPONSE REQUIRED

1994

Frame 2

The Pitch Steering Mode switch operation will be covered at this time. The PITCH STEER switch (A in the figure below) is a three position switch marked ALT REF (altitude reference) and TF (terrain following). This switch is used in conjunction with the MODE SEL switch B. The PITCH STEER switch is solenoid held in either the ALT REF or TF position. In the event that the PITCH STEER switch is being solenoid held in either position and the MODE SEL switch is positioned to a mode that does not use the Pitch Steer Bar, the PITCH STEER switch will automatically go the OFF position; solenoid deenergized.


B
WHEELS
MODE SEL
CRS SEL NAV
BOMB NAV
CRS LINE
PITCH STEER
ALT REF
TACAN
MAN CRS
AILA
PUSH TO TURN
MAN HDG
OFF
A
ILS
TKR RV
TF
OFF

Place a checkmark (✓) in front of each of the true statements below.

___1. The PITCH STEER switch is a two position switch.

___2. The PITCH STEER switch operates in conjunction with the MODE SEL switch.

___3. When not being used with a compatible MODE SEL position, the PITCH STEER switch goes to the OFF position.

Frame 3

The Altitude Reference (ALT REF) submode aids the pilot in maintaining a predetermined altitude. With the PITCH STEER switch in the ALT REF position, pitch steering command signals are applied to the "Pitch Steer Bar" in the ADI. When the aircraft flies below a predetermined altitude, the pitch steer bar on the ADI deflects upward. This indicates to the pilot that he must fly up. As the aircraft reaches the desired altitude, the pitch steer bar returns to the center position. Refer to the illustrations in HO 405, page 3. Figure A shows the aircraft below the reference altitude with the pitch steer bar showing a fly up command. Figure B shows the aircraft at the reference altitude with no steering bar displacement. Figure C shows the aircraft above reference altitude with a fly down command on the ADI.

Place a checkmark (✓) in front of each of the true statements below.

___1. The ALT REF submode is selected for maintaining a predetermined flight direction.

___2. When using the ALT REF position on the PITCH STEER switch, steering signals are applied to the Pitch Steering Bar.

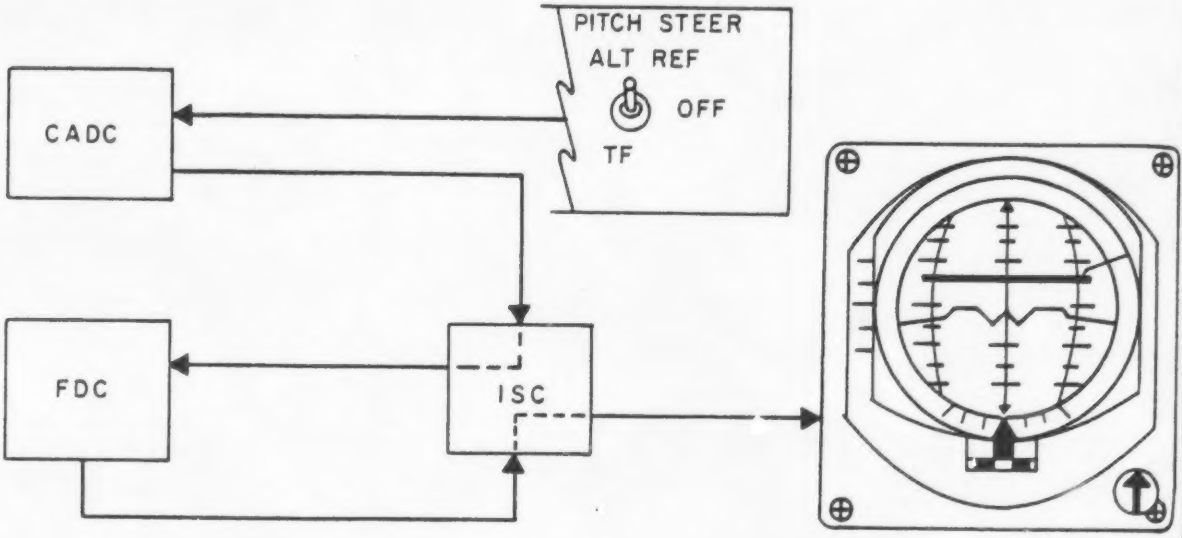
___3. With the PITCH STEER switch in the ALT REF position, the pitch steering bar deflects up if the aircraft goes below a predetermined altitude.

Answers to Frame 2: ___1. ✓ 2. ✓ 3.

1996

Frame 4

To obtain a reference altitude, the pilot flies to the altitude he desires to maintain. When the desired altitude is reached, the PITCH STEER switch is placed in the ALT REF position. This engages a clutch in the central air data computer (CADC). The CADC system provides "differential altitude signals to the Instrument Set Coupler." This signal is routed through the ISC (Instrument Set Coupler) to the Flight Director Computer (FDC) and applied from the FDC to the ADI Pitch Steering Bar. Refer to the block diagram below. Visually trace the signal from the CADC to the ISC, and FDC and apply this to the pitch steering bar in the ADI.



Place a checkmark (✓) in front of each of the true statements below.

___1. To obtain a reference altitude, the aircraft is flown to the desired altitude and the PITCH STEER switch is positioned to ALT REF.

___2. When using the ALT REF submode, differential altitude signals are applied to the CADC.

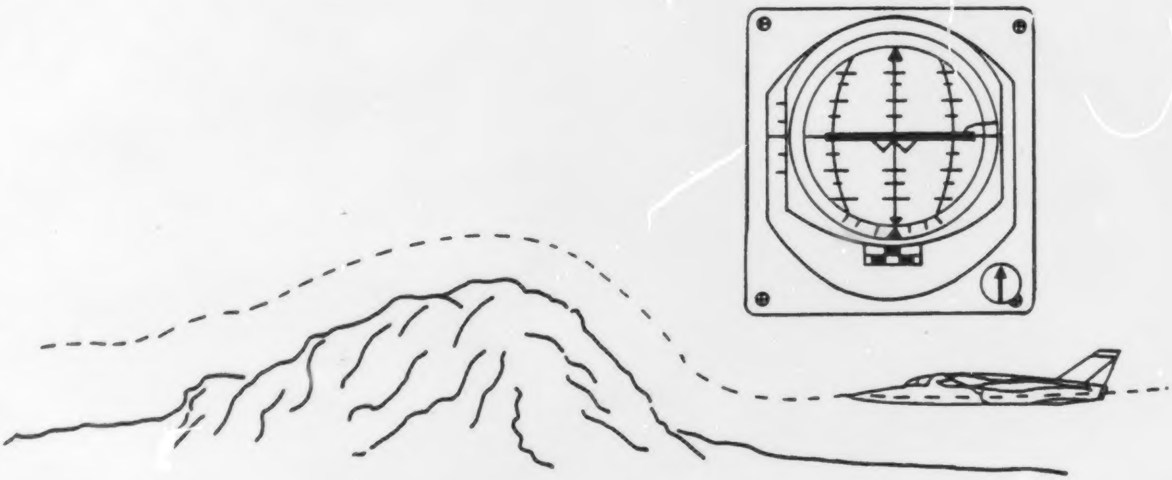
___3. Differential altitude signals are routed through the ISC to the FDC and applied to the ADI pitch steering bar.

Answers to Frame 3: ___1. _✓_2. _✓_3.

2091

Frame 5

The TF submode is used when it is necessary to fly at low altitudes. This mode enables the aircraft to approach a bombing target at minimum altitudes. In this mode, aircraft altitude is referenced to ground level. If ground elevation increases or decreases, the aircraft altitude must change proportionally. The illustration below shows an aircraft in the TF mode.



Place a checkmark (✓) in front of each of the true statements below.

___1. The TF submode is used to maintain a preset altitude above ground level.

___2. In the TF submode, aircraft altitude is referenced to sea level.

___3. This mode enables the pilot to approach a target at minimum altitude.

Answers to Frame 4: ✓ 1. ___ 2. ✓ 3.

Frame 6

When the TF submode is selected, information from the terrain following radar (TFR) is routed through the ISC to the Pitch Steering Bar in the ADI. TF signals do not go through the Flight Director Computer. If the TFR is in the manual mode, the Pitch Steering Bar provides fly up or fly down indications to the pilot. Refer to the illustration on page 4 in HO 405. In the automatic mode, TFR signals cause the aircraft to automatically fly up or down to maintain a preset altitude above ground level. Figure A in HO 405 shows an aircraft approaching a mountain, the pitch steering bar is deflected up telling the pilot to fly up. Figure B shows the aircraft at the top of the mountain with the ADI showing a steer down indication. Figure C shows that the aircraft has leveled out with no steering commands being indicated by the ADI.

Place a checkmark (✓) in front of each of the true statements below.

___1. In the TF submode, input signals to the Pitch Steering Bar are received from the Central Air Data Computer.

___2. With the Pitch Steering switch in the TF position, input signals are not processed by the Flight Director Computer.

___3. When the Pitch Steering switch is in the TF position, the pilot can fly the aircraft manually or the aircraft can hold a fixed position automatically.

Answers to Frame 5: _✓_1. ___2. _✓_3.

Frame 7

The instrument set coupler MODE SEL switch provides a means of selecting any one of ten major modes of operation. In the OFF position, the bank steering bar, glide slope pointer and warning flags are biased out-of-view. The operation of the pitch steering bar is determined by the position of the PITCH STEER switch on the ISC. Refer to HO 405 page 1 and 2 in order to determine which ADI and HSI indicating sections are being used and what they indicate in the OFF position.

Place a checkmark (✓) in front of each of the true statements below.

___1. When the MODE SEL switch is in the OFF position, no input signals are applied to the Bank Steering Bar.

___2. With the MODE SEL switch in the OFF position, the operation of the Pitch Steering Bar is determined by the position of the PITCH STEER switch.

Answers to Frame 6: ___1. _✓_2. _✓_3.

2000

Frame 8

The next position on the MODE SEL switch is the ILS (Instrument Landing System) mode. This mode provides the capability of making instrument approaches and landings on runways equipped with localizer and glide slope radio receivers. Refer to the illustration on page 6 in HO 405. The localizer and glide slope signals are received by the instrument set coupler, processed and sent to the flight director computer. After being processed by the FDC, these signals are applied to indicating sections of the ADI and HSI.

Refer to HO 405 pages 1 and 2 to determine which ADI and HSI indicating sections are used in the ILS mode. The illustration on page 5 in HO 306 shows a block diagram of components used in ILS. Study the inputs and outputs of each component.

Place a checkmark (✓) in front of each of the true statements below.

___1. The ILS mode of operation assists the pilot in making instrument approaches to runways.

___2. Signals from localizer and glide slope receivers are applied directly to the ADI and HSI.

___3. The Flight Director Computer processes ILS radio signals before they are applied to the ADI and HSI.

Answers to Frame 7: _✓_1. _✓_2.

2005

Frame 9

Localizer radio transmitters are located at the far end of the runway. The localizer signals provide a reference for aligning the aircraft to the centerline of the runway. Signals from the aircraft localizer receiver are applied to the HSI Course Deviation Indicator (CDI) and to the localizer warning flag. The CDI indicates deviation to the left or right of the runway centerline. The localizer signal applied to the localizer warning flag, biases the flag out of view, indicating that the deviation indications are reliable.

Study the illustration on page 7 of HO 405. Notice the relationship between the aircraft and localizer signal and miniature aircraft and CDI.

Using the illustration on page 7 of HO 405 complete the following statements by underlining the correct responses.

1. The localizer transmitter is located at the (near/far) end of the runway.

2. The CDI is indicating that the aircraft is to the (left/right) of the runway centerline.

3. The localizer warning flag is indicating that the signal is (reliable/unreliable).

Answers to Frame 8: ✓ 1. ___2. ✓ 3.

Frame 10

With the MODE SEL switch in the ILS position, localizer signals are mixed with altitude and other pertinent steering data in the flight director computer. The FDC provides a localizer steering command signal which is displayed on the bank steering bar in the ADI. The bank steering bar deflects left or right to indicate the direction to steer to the centerline of the runway. If the aircraft is to the left of the runway centerline, the bar deflects right. This indicates that a right turn is necessary to get back to the centerline. Study the illustration on Page 8 of HO 405.

Place a checkmark (✓) in front of each of the true statements below.

___1. Localizer signals are applied to the ADI pitch steering bar.

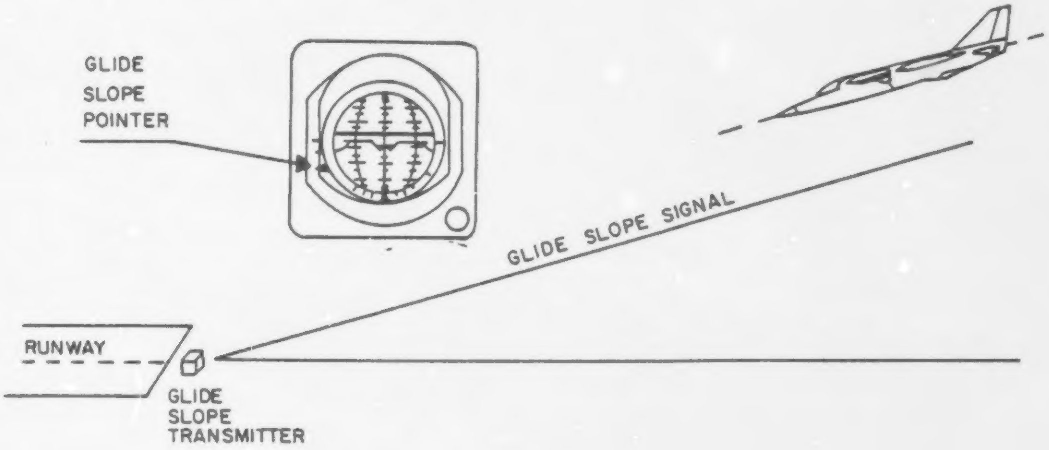
___2. The ADI bank steering bar indicates the direction to fly in order to get on the runway centerline.

___3. When the aircraft is to the right of the runway, the steering bar deflects right.

Answers to Frame 9: 1. far 2. right 3. unreliable

The glide slope transmitter is located at the near end of the runway. This transmits a radio signal at an angle from the end of the runway. This signal provides the pilot with a glide angle to guide the aircraft down to the runway. The glide slope pointer on the ADI indicates to the pilot the relationship between his aircraft and the glide slope signal. If the aircraft is above the signal, the pointer moves below center.

Study the illustration on Page 9 of HO 405, notice the relationship between the aircraft and glide slope signal, and the ADI miniature aircraft and glide slope pointer.



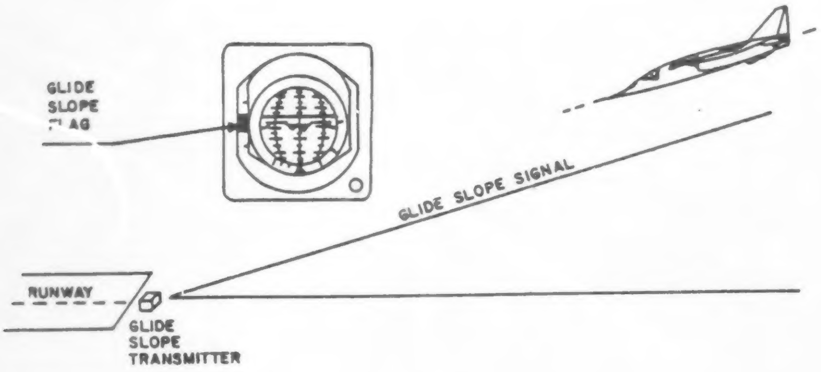
Using the illustration above, complete the following statements by underlining the correct responses.

1. The glide slope transmitter is located at the (far/near) end of the runway.
2. The ADI glide slope pointer is indicating that the aircraft is (above/below/on) the glide slope signal.

Answers to Frame 10: ___1. _✓_2. ___3.

Frame 12

The glide slope signal which is applied to the glide slope pointer is also applied to the glide slope warning flag. The glide slope warning flag will remain out of view as long as the deviation signal applied to the glide slope pointer is providing a reliable indication.


GLIDE SLOPE FLAG
GLIDE SLOPE SIGNAL
RUNWAY
GLIDE SLOPE TRANSMITTER

Place a checkmark (✓) in front of each of the true statements below.

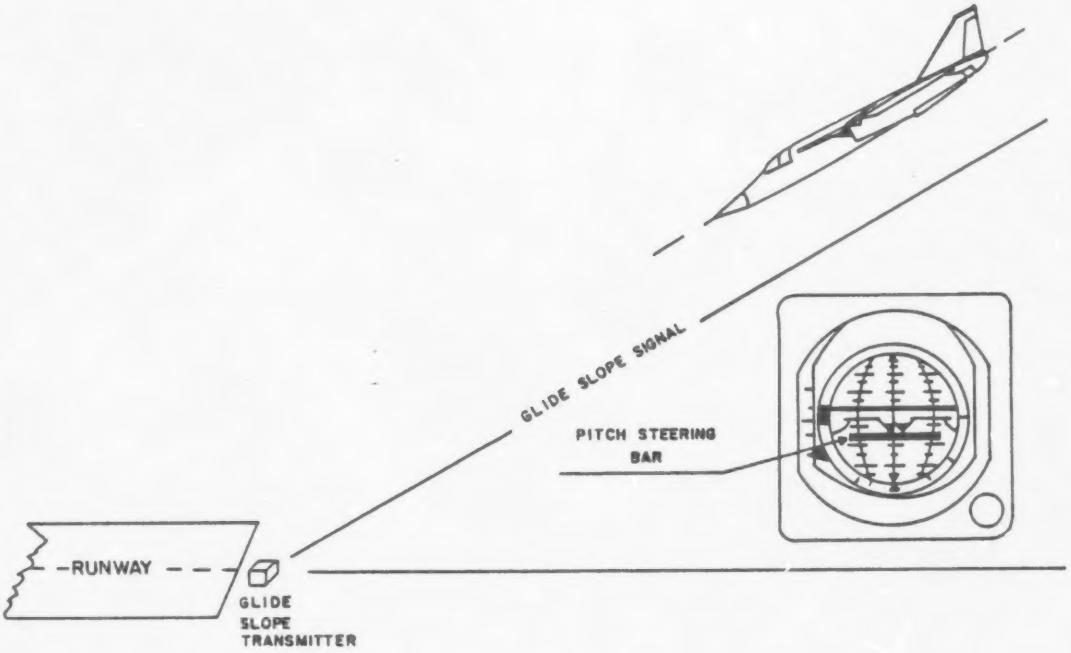
___1. Glide slope signals are applied to the ADI glide glope pointer and glide slope warning flag.

___2. The glide slope warning flag is in view when the glide slope signal is reliable.

Answers to Frame 11: 1. near 2. above

Frame 13 2005

Deviation data from the glide slope signal is also combined with attitude signals in the FDC. The resulting glide slope steering commands from the computer are applied to the pitch steering bar. If the aircraft is above the glide slope signal, the pitch steering bar deflects down. This indicates to the pilot he must steer down to get back to the glide slope signal.


GLIDE SLOPE SIGNAL
PITCH STEERING BAR
RUNWAY
GLIDE SLOPE TRANSMITTER

Place a checkmark (✓) in front of each of the true statements below.

___1. The glide slope signal is combined with heading signals in the FDC.

___2. The computer signal applied to the pitch steering bar provides steer up - steer down indications.

Answers to Frame 12: ✓1. ___2.

2100

2006

Frame 14

Complete the tasks below. If you miss any of the questions, return to the appropriate frame to insure a complete knowledge of the material before continuing with the text.

A. Place a checkmark (✓) in front of each of the true statements below.

___1. The pitch steer switch provides a selection for ten major modes of operation.

___2. ALT REF, TF, and OFF are the positions on the PITCH STEER switch.

___3. The ALT REF position is selected when maintaining a predetermined altitude above sea level.

___4. When in the ALT REF position, the signals applied to the PITCH STEER bar are being received from terrain following radar.

___5. The terrain following submode is used when approaching the target at a preselected altitude which is referenced to ground level.

___6. With the PITCH STEER switch in the TF position, signals to the pitch steering bar are received from terrain following radar.

___7. The MODE SEL switch is the control used for selecting submodes of operation.

___8. When the MODE SEL switch is in the OFF Position, no inputs are applied to the bank steering bar.

___9. With the MODE SEL switch in the OFF Position, operation of the pitch steering bar is determined by the position of the PITCH STEER switch.

__10. The OFF position is selected to allow command inputs to operate both the bank and pitch steering bars.

B. Using the illustration on Page 10 of HO 405 complete the following statements by underlining the correct responses.

11. In the illustration on Page 10 of HO 405, the aircraft is to the (right/left) of the localizer signal.

12. The CDI is displaced to the (left/right) of the miniature aircraft.

13. A (right/left) turn is needed to get back to the localizer signal.

2007

14. The localizer transmitter is located at the (near/far) end of the runway.

15. In the illustration, the localizer warning flag is indicating that the signal is (reliable/unreliable).

C. Using the illustration on page 11 of HO 405, complete the following statements by underlining the correct responses.

16. In the illustration, the aircraft is (above/below) the glide slope signal.

17. The glide slope transmitter is located at the (near/far) end of the runway.

18. In the illustration, the aircraft must fly (up/down) to get back to the glide slope signal.

19. The glide slope pointer indicates that the aircraft is (below/above) the glide slope signal.

20. The glide slope warning flag is indicating that the glide slope signal is (reliable/unreliable).

Answers to Frame 13: _____1. __✓__2.

2102

2008

The Airborne Instrument Landing and Approach Mode (AILA) provides the capability of making instrument approaches and landings on runways NOT equipped with localizer and glide slope transmitters. Simulated localizer and glide slope signals are provided by the bombing-navigation and attack radar systems. Simulated localizer and glide slope signals operate the same ADI and HSI indicating sections used when landing in the ILS mode of operation.

Refer to Pages 1 and 2 in HO 405 to review what signals are applied to the ADI and HSI indicating sections in the AILA mode.

Place a checkmark (✓) in front of each of the true statements below.

___1. In the AILA mode, inputs to the glide slope pointer and steering bars are received from glide slope and localizer receivers.

___2. The AILA mode provides the capability of making instrument approaches to runways equipped with localizer and glide slope.

___3. Indications during the AILA mode are the same as in ILS mode.

Answers to Frame 14:

A. ___1. ✓ 2. ✓ 3. ___4. ✓ 5. ✓ 6. ___7. ✓ 8. ✓ 9. ___10.

B. 11. right 12. left 13. left 14. far 15. unreliable

C. 16. below 17. near 18. up 19. below 20. reliable

When in the TACAN (Tactical Air Navigation) Mode, the flight director system receives input signals from a TACAN radio transmitter. TACAN signals enable the pilot to fly anywhere in the country while being provided with radio signals for cross-country navigation. TACAN radio transmitters are located throughout the country. These stations transmit radio signals in all directions which radiate from the station (transmitter) like the spokes of wheel. (Refer to the illustration of Page 12 of HO 405.) The pilot can select and fly anyone of the 360 signals (radials or courses).

Place a checkmark (✓) in front of each of the true statements below.

___1. The TACAN Mode provides the capability for cross-country navigation.

___2. TACAN provides 270 radials which can be used as guides for navigation.

Answers to Frame 15: ___1. ___2. _✓_3.

Frame 17

When using a TACAN station as a directional reference, the pilot uses the course set knob to set the course counter and arrow to the TACAN radial (radio signal) he desires to fly. If the aircraft is on the selected radial, the course deviation indicator (CDI) will be centered. If the aircraft is not on the radial, the CDI will be deflected to the left or right. A red alarm flag (deviation bar alarm flag) is located under the head of the course arrow. This flag comes into view in event the TACAN signal is unreliable or the aircraft is too far from the selected radial. Study the illustration on page 13 in HO 405.

Using the illustration on page 13 in HO 405, complete the following statements by underlining the correct responses.

1. The aircraft is displaced to the (left/right) of the selected TACAN radial.
2. (000/060/075) is the selected course set into the course counter.
3. The (CDI/course arrow) is indicating lateral displacement from the selected radial.
4. The deviation bar alarm flag is indicating a (reliable/unreliable) TACAN signal.

Answers to Frame 16: ✓ 1. ___ 2.

Frame 18

A TO-FROM arrow, which is located under the course arrow, indicates to the pilot whether the aircraft is flying to or from the TACAN station. When the aircraft is flying to the station, the TO-FROM arrow points towards the course arrow head. When flying away from the station, the TO-FROM arrow points towards the course arrow tail.

Refer to the illustration on Page 13 of HO 405, locate the TO-FROM arrow and notice the relationship between the aircraft and the TACAN station.

Complete the following statements below by underlining the correct responses. You may use the illustration on page 13 of HO 405.

1. When flying to a TACAN station, the TO-FROM arrow deflects (up/down).

2. In the illustration, the aircraft is flying (to/from) the TACAN station.

Answers to Frame 17: 1. left 2. 000 3. CDI 4. unreliable

2012

Frame 19

Relative bearing to a TACAN station is indicated by the BEARING POINTER. Relative bearing is the position of the TACAN station in relation to the aircraft direction of flight.

Refer to page 14 of HO 405. (Note the position of the bearing pointer against the compass card.)

The distance to the TACAN station is indicated by the DISTANCE COUNTER. Bearing and distance to TACAN are displayed in all modes of operation if the pilot has set in a TACAN frequency of a station.

Using the illustration on page 14 of HO 405, complete the following statements by underlining the correct responses.

1. The (000/010/040/060) TACAN radial has been selected as a directional reference.
2. The aircraft is displaced to the (left/right) of the selected radial.
3. The aircraft is (025/075/150) miles and flying (to/from) the TACAN station.
4. (010/040/060) is the relative bearing to the N station.

Answers to Frame 18: 1. up 2. to

2197

The ADI-Bank steering bar provides the pilot with steering commands to maintain the selected course set into the course counter. If the aircraft drifts to the left, the bar deflects right, indicating a right bank is necessary to steer back to the course. The course warning flag on the ADI will come into view in the event the signal is unreliable.

Refer to Page 1 in HO 405 to determine which ADI indicating sections are being used and what indications the ones being used are providing.

Using the illustration on Page 15 of HO 405, complete the following statements by underlining the correct responses.

1. The HSI indicates
    a. that the aircraft is to the (left/right) of the selected radial.
    b. (180/200/290/310) is the relative bearing to the TACAN station.
    c. (000/030/090/180) is the selected radial.
    d. that the aircraft is (005/025/050/100) miles (to/from) the TACAN station.
    e. that the TACAN signal (is/is not) reliable.
    f. The TO-FROM arrow is indicating (to/from) the station.
2. The ADI indicates
    a. that a (left/right) bank is needed to fly back to the selected radial.
    b. that the input signal to the bank steering bar is (reliable/unreliable).

Answers to Frame 19: 1. 060 2. right 3. 075, to 4. 040

Frame 21

This frame is a review exercise for the TACAN mode of operation. If any questions are missed, refer back to the appropriate frame to insure a complete understanding of the materials presented before continuing with the text.

A. Place a checkmark (✓) in the front of each of the true statements below.

___1. The TACAN mode is used primarily for landing on runways not equipped with localizer and glide slope.

___2. 360 degrees or radials are provided with each TACAN station.

___3. The direction the pilot desires to fly to or from a TACAN station must be set into the course counter.

___4. When in the TACAN mode, the course arrow is controlled by a command signal.

___5. The course deviation indicator, indicates deviation to the left or right of a TACAN radial.

B. Using the illustration on page 16 in HO 405 complete the following statements by underlining the correct responses.

6. In the illustration on page 16 of HO 405, the (010/045/090) radial has been selected by the pilot.

7. The aircraft is to the (left/right) of the selected radial.

8. Relative bearing to the TACAN station is (000/015/030) degrees.

9. Distance to the TACAN station is (025/050/100) miles.

10. The TO-FROM arrow is indicating that the aircraft is flying (towards/away) from the station.

Answers to Frame 20: 1. a. right b. 290 c. 090 d. 050, from

e. is f. from 2. a. left b. reliable

The next mode to be covered is the Bomb-Navigation (Bomb/Nav) Mode. This mode is used to fly to a precomputed weapons (bomb) release point or to a preselected destination. Prior to a flight in which the Bomb/Nav mode is used, longitude, latitude and other information pertaining to the departure point and destination must be fed into the Bomb/Nav computer. During the flight, the computer monitors aircraft speed, drift, distance and other information. By constantly updating these data, the aircraft position in relation to the precomputed course and destination is always known.

Place a checkmark (✓) in front of each of the true statements below.

___1. Before a Bomb/Nav flight, the flight director computer must be programmed.

___2. Pertinent data is constantly maintained current by the Bomb/Nav computer.

___3. The Bomb/Nav mode is used during instrument approaches.

Answers to Frame 21: ___1. ✓2. ✓3. ___4. ✓5.

6. 010 7. left 8. 030 9. 050 10. towards

2016

Frame 23

During a Bomb/Nav flight, the heading set knob and course arrow are not manually set. The heading marker and course arrow are controlled by command signals from the Bomb/Nav system. The heading marker indicates the computed course to destination or target (bomb release point). The course arrow indicates current magnetic ground tract. Magnetic ground tract is the direction the aircraft is moving in relation to the ground. The illustration on page 17 of HO 405 shows an aircraft with its nose into the wind to maintain course. Because the aircraft is on course, the computed course indicated by the heading marker, and ground tract indicated by the course arrow, are the same.

Place a checkmark (✓) in front of each of the true statements below.

___1. In the Bomb/Nav mode, the course arrow always indicates magnetic heading.

___2. Magnetic ground tract is always the direction the aircraft is moving.

___3. Computed course to destination is indicated by the heading marker.

___4. Controlling signals applied to the heading marker and course arrow are produced by the Bomb/Nav system.

Answers to Frame 22: ___1. _✓_2. ___3.

In the illustration on page 18 of HO 405, figure A shows the aircraft on course with magnetic heading, ground tract and computed course all the same. Figure B shows that the same aircraft has drifted to the right of the course. The course arrow is indicating magnetic ground tract (the direction the aircraft is drifting due to wind). The heading marker is indicating a new computed course to target. The course deviation indicator has moved to the left (showing the aircraft's displacement from the precomputed course).

Refer to pages 1 and 2 of HO 405 to determine what other ADI and HSI indicating sections are being used. Note what each indicates to the pilot.

Complete the following statements below by underlining the correct responses.

1. The (Course Arrow/Course Deviation Indicator) indicates lateral drift from a computed course.

2. Whenever the aircraft deviates from course, the (miniature aircraft/course deviation indicator/course arrow) moves to the left or right.

3. Signal reliability to the ADI is indicated by the (attitude warning flag/course warning flag).

4. In the Bomb/Nav mode, the ADI Bank Steering Bar indicates (Command Steer to destination/Command Steer to course line).

Answers to Frame 23: ___1. _✓_2. _✓_3. _✓_4.

Frame 25

When in the Bomb/Nav mode, if the aircraft drifts off course (as shown on Page 18 of HO 405) the Bomb/Nav computer will compute a new course to target or destination. As the new course is computed the heading marker will indicate the new course. The bank steering bar in the ADI will deflect, telling the pilot the direction in which to steer to maintain the new course. The illustration on Page 19 of HO 405 shows the heading marker at the new computed course and the ADI bank steering bar deflected to indicate a left turn to the new course is necessary.

Using the illustration on Page 19 of HO 405, complete the following statements by underlining the correct responses.

1. When the aircraft drifts off course, it is (steered back to course/flown on a new course to destination).

2. In the illustration, the heading marker indicates the (old computed/new computed) course.

3. The bank steering bar indicates that a (left/right) turn is necessary.

Answers to Frame 24: 1. Course deviation indicator 2. course deviation indicator. 3. course warning flag 4. command steer to destination

Frame 26

This frame is a review exercise for the Bomb/Nav mode of operation. If any questions are missed, refer back to the appropriate frame to insure a complete understanding of the material presented.

Place a check (✓) in front of each of the true statements below.

___1. The Bomb/Nav mode is used for navigation to a bomb release point.

___2. When in this mode, the course arrow and counter indicate command heading.

___3. Magnetic ground tract is displayed by the position of the course arrow.

___4. In this mode, the heading marker cannot be manually set.

___5. The course deviation indicator indicates lateral drift from a precomputed course.

___6. The heading marker is controlled by signals from the bomb/nav system.

___7. Before a Bomb/Nav mission, the flight director computer must be programmed.

___8. The ADI bank steering bar indicates the direction of turn to steer to destination.

___9. Whenever the aircraft drifts off course, the miniature aircraft moves left or right.

___10. Magnetic ground tract is the direction the aircraft is moving in relation to the ground.

Answers to Frame 25: 1. flown on a new course to destination

2. new computed 3. left

Frame 27

The course select navigation (CRS SEL NAV) mode of operation provides the capability of approaching a preselected destination along a route other than the most direct. This enables the pilot to avoid bad weather, obstacles such as mountains, and enemy antiaircraft weapons. The illustration on Page 20 in HO 405 shows an aircraft approaching a target. This aircraft is flying with the mode switch in CRS SEL NAV and the pitch steer switch in the TF submode. Because it is necessary to approach the target at a very low altitude, the mountains must be avoided. An alternate route must be selected that will allow the aircraft to fly around, rather than over, the mountains. Refer to the illustration on page 20 in HO 405.

Place a checkmark (✓) in front of each of the true statements below.

___1. The CRS SEL NAV mode is used when approaching a target on the most direct route.

___2. The CRS SEL NAV mode is used when it is necessary to avoid obstacles.

Answers to Frame 26: _✓_1. ___2. _✓_3. _✓_4. _✓_5. _✓_6.
___7. _✓_8. ___9. _✓_10

Frame 28

In the CRS SEL NAV mode of operation, the course arrow and counter are manually set by the pilot. Using the course set knob, the pilot sets the course arrow to an alternate course which enables him to avoid an obstacle (mountains, gun emplacements, etc.). When the course arrow has been set to the new desired course, the course deviation indicator indicates the aircraft displacement from the new manually selected course. Refer to the illustration on page 21 in HO 405.

Using the illustration on page 21 in HO 405, complete the following statements by underlining the correct responses.

1. The precomputed course to destination is (000,030,045,060) degrees.

2. Course deviation is indicated by the (heading marker, course arrow, course deviation indicator).

3. The new desired course is set by the (bomb/nav signal, pilot).

Answers to Frame 27: ___1. _✓_2.

2022

Frame 29

The bank steering bar in the ADI provides the necessary steering commands to make good the manually selected course. Refer to the illustration on page 22 in HO 405. The illustration in the upper left hand corner shows an aircraft in three different positions (A, B, and C) as it flies around an obstacle to a target. Three groups of indicators are shown for each aircraft position and are labeled A, B, and C. The ADI and HSI labeled A show the indications the pilot would see when he is flying in position A. Magnetic heading is 045 degrees and he has set the course arrow to a desired course of 015 degrees. The ADI bank steering bar indicates a right steering command. Aircraft B shows that the pilot has made the turn and the course deviation indicator shows that the aircraft is approaching the new course. The indications in C show that the aircraft has made the turn and is now flying towards the target. All indicating sections are centered at the top lubber line.

Place a checkmark (✓) in front of each of the true statements below. Refer to page 22 in HO 405.

___1. The bank steering bar in figure A indicates that a left bank is necessary.

___2. Figure B indicates a left bank is necessary.

___3. Figure C indicates that the aircraft is to the right of course.

Answers to Frame 28: 1. 060 2. course deviation indicator

3. pilot

The Manual Heading (MAN HDG) mode is used when the pilot elects to fly the aircraft without the aid of Bomb/Nav signals applied to the heading marker. In this mode of operation, the pilot uses the heading set knob to control the position of the heading marker. The heading marker is set to the heading that the pilot desires to fly. By steering the aircraft until the heading marker is at the top lubber line, the aircraft is turned to the new desired heading. Study the illustration on page 23 in HO 405.

Using the illustration on page 23 in HO 405, complete the following statements below by underlining the correct responses.

1. In figure A, the current magnetic heading is (000, 045, 090) degrees.

2. The pilot uses the (HDG set knob, course set knob).

3. The pilot has set his desired heading to (000, 045, 090) degrees.

4. By steering the heading marker to the top lubber line, the aircraft will be flying (Fig B) (000, 045, 090) degrees.

Answers to Frame 29: ___1. ✓ 2. ___3.

Frame 31

When in the Manual Heading mode, and the Bomb/Nav system is in operation, the course arrow CANNOT be manually set. The Bomb/Nav signal applied to the course arrow will cause it to indicate current magnetic ground tract. Refer to the illustration on page 24 of HO 405. The pilot has set the heading marker to 080 degrees on the compass card. This heading steers the aircraft nose into the wind sufficiently to eliminate drift. This causes the aircraft to move in the direction the pilot desires to fly. At this time, magnetic ground tract is the direction the pilot desires to fly. The course counter provides a digital readout of the current ground tract.

Place a checkmark (✓) in front of each of the true statements below.

___1. The Bomb/Nav system cannot control the course arrow when the flight director system is in the MAN HDG mode.

___2. When in the Manual Heading mode, it is possible for the course arrow and counter to indicate current ground tract.

___3. The course counter provides a digital readout of aircraft ground tract.

Answers to Frame 30: 1. 045 2. HDG set knob 3. 090 4. 090

If the Bomb/Nav system is inoperative, the course set knob is used to set the desired heading into the course select window. This provides a digital readout of the aircraft magnetic heading, and will have the heading marker and course arrow aligned. Aligning the heading marker and course arrow reduces the possibility of heading confusion. Refer to pages 1 and 2 of HO 405 to review which ADI and HSI indicating sections are used in the MAN HDG mode, and what they indicate to the pilot.

Place a checkmark (✓) in front of each of the true statements below.

___1. The course arrow can be manually set when the Bomb/Nav system is not operating.

___2. With the course arrow set to desired heading, the heading marker and course arrow should indicate the same.

Answers to Frame 31: ___1. ✓2. ✓3.

2026·

Frame 33

When the pilot sets the heading marker to any desired heading other than the current magnetic heading, a heading error signal is generated in the HSI. This signal is sent through the FDC and ISC to the ADI. This signal is applied to the ADI bank steering bar to provide steering commands. The steering pointer aids the pilot in steering the aircraft to the desired heading which the heading marker has been set to on the compass card. The illustration on page 25 of HO 405 shows the heading error output from the HSI being applied to the FDC and to the ADI bank steering bar.

Place a checkmark (✓) in front of each of the true statements below.

___1. Heading error signals are produced by the HSI when the HDG marker is at the top lubber line.

___2. Heading error is processed in the bomb/nav system before being applied to the ADI.

___3. Signals applied to the bank steering bar assist in keeping the aircraft on the desired heading.

Answers to Frame 32: _✓_1. _✓_2.

Frame 34

This frame is a review exercise, answer the questions below and check your responses. If any questions are missed, return to the appropriate frame to insure a complete knowledge of the materials presented. When you are sure you have a complete understanding, continue with the text.

Match the mode or submode of operation in Column II to its purpose in Column I. Place the appropriate letter from Column II in the space provided in Column I.

Column I

___1. Enables a change from a computed course to a manually selected alternate course.

___2. Used for landing on runways equipped with localizer and glide slope.

___3. Keeps the aircraft at a preselected altitude, above sea level.

___4. Used when radio signals or bomb/nav are not available.

___5. Holds the aircraft at a preselected altitude above ground level.

___6. Used when landing on runways NOT equipped with localizer and glide slope transmitters.

___7. Used when flying to a preselected bomb release point.

___8. This mode biases the bank steering bar out of view.

___9. Uses radio signals for cross country navigation where ground transmitters are provided.

___10. Used when making low altitude approaches to a target.

Column II

a. Altitude reference

b. Terrain following

c. Mode select "OFF"

d. ILS

e. AILA

f. TACAN

g. Bomb/Nav

h. CRS SELECT NAV

i. MAN HDG

Answers to Frame 33: ___1. ___2. ✓ 3.

Frame 35

The COURSE LINE STEERING (CRS LINE) mode of operation provides most of the same indications as the Bomb/Nav mode. When flying in the Bomb/Nav mode, if the aircraft drifts off course, the bank steering bar will steer the aircraft on a new (shortest) course to destination. In the CRS LINE mode, steering information on the bank steering bar provides steering commands which will steer the aircraft back to the original precomputed course (NCI destination) by the shortest route. The illustration on page 26 of HO 405 shows an aircraft off course and the direction the pilot must fly to get back to the course.

Place a checkmark (✓) in front of each of the true statements below.

___1. The ADI and HSI provide all the same indications in the CRS LINE mode as in the Bomb/Nav mode.

___2. In the CRS LINE mode, steering information directs the aircraft back to the precomputed course.

___3. In the Bomb/nav mode, steering commands direct the aircraft to the destination.

Answers to Frame 34: h 1. d 2. a 3. i 4. b 5.

e 6. g 7. c 8. f 9. b 10.

Frame 36

The final mode to be covered is Tanker Rendezvous (TKR RV). This mode position is used to steer the aircraft to a refueling tanker. In this mode, the heading marker is controlled by a signal from the attack radar set. The position of the heading marker, against the compass card, provides the pilot with a bearing indication to the tanker aircraft. Refer to the illustration on page 27 of HO 405. Note the position of the aircraft in relation to the tanker and the position of the heading marker against the compass card.

Place a checkmark (✓) in front of each of the true statements below.

___1. TKR RV provides steering capability to a tanker for air refueling.

___2. In this mode, the heading marker is driven by a signal from the navigation computer.

___3. Bearing of the tanker is indicated by the heading marker.

___4. The pilot must set the heading marker to his desired course to the tanker.

Answers to Frame 35: ___1. _✓_2. _✓_3.

Frame 37

In TKR RV mode, both bank and pitch steering bars on the ADI are used. A heading error signal is fed, from the attack radar, to the flight director computer. The FDC sends this signal to the ADI bank steering bar. The bank steering bar indicates the necessary commands to steer the aircraft to the tanker. The pitch steering bar will indicate the necessary pitch steering correction to fly to the same altitude as the tanker. Refer to pages 1 and 2 in HO 405 to determine what the remaining ADI and HSI indicating sections indicate to the pilot.

Place a checkmark (✓) in front of each of the true statements below.

___1. The bank steering bar is biased out of view in the TKR RV mode.

___2. In this mode the course deviation indicates lateral drift from the computed course.

___3. The pitch steering bar is used to fly to the tanker altitude.

Answers to Frame 36: _✓_1. ___2. _✓_3. ___4.

This frame is a review exercise; answer the questions and check your responses. If any questions are missed, return to the appropriate frame to insure a complete knowledge of the material presented.

A. Complete the following statements by underlining the correct responses.

1. The pitch steer switch is a (one/two/three) position switch.

2. The pitch steer switch provides pitch steering in (major modes/submodes) of operation.

3. The (ALT REF/TF) submode is used holding a fixed altitude above ground level.

4. The (ALT REF/TF) submode is referenced to sea level.

5. The (mode select switch/pitch steer switch) determines the operation of the pitch steer bar.

6. When making approaches to runways equipped with glide slope and localizer, the pilot would select the (ILS/AILA/TACAN) mode of operation.

7. The (TACAN/BOMB NAV/CRS LINE) mode is used for cross country navigation using radio signals as directional references.

8. When it is necessary for the aircraft to avoid obstacles. the pilot would select the (BOMB NAV/MAN HDG/CRS SEL NAV) mode of operation.

9. When flying to a bomb release point and no deviations from the precomputed course are necessary, the (BOMB NAV/CRS LINE/CRS SEL NAV) mode would be selected.

10. When flying with no radio or navigation signals needed, the pilot would select the (BOMB NAV/CRS LINE/MAN HDG) mode of operation.

B. Match the ADI and HSI indicating sections to the indication it provides by placing the appropriate letter from Column II in the spaces provided in Column I.

Column I

___1. Indicates magnetic heading in all modes of operation.

___2. Is manually set to a runway heading when landing.

___3. Moves to the course arrow tail when the aircraft is flying away from a TACAN station.

___4. Indicates computed course when the mode SEL SWITCH is in a bombing mode.

___5. Is controlled by a signal transmitted from the near end of the runway.

___6. Indicates bearing to a TACAN station.

___7. Provides nose up, nose down steering commands.

___8. Indicates the bearing to a tanker when the mode SEL SWITCH is in TKR RV.

___9. Indicates lateral deviation from a precomputed course.

___10. Provides left or right steering commands for maintaining a course.

Column II

a. Bank steering bar

b. Bearing pointer

c. Compass card

d. Course arrow and counter

e. Course deviation indicator

f. Glide slope pointer

g. Heading marker

h. Pitch steering bar

i. TO-FROM arrow

Answers to Frame 37: ___1. ___2. ✓3.

2033

Answers to Frame 38: A. 1. three 2. submode 3. TF 4. ALT REF 5. Pitch steer switch 6. ILS 7. TACAN 8. CRS SEL NAV 9. Bomb/Nav 10. MAN HDG B. c 1. d 2. i 3. g 4. f 5. b 6. h 7. g 8. e 9. a 10.

2128

2034

HANDOUT

3ABR32531-HO-404
3ABR32632B-HO-504

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

FLIGHT DIRECTOR SYSTEMS
(MODES OF OPERATION)

12 August 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71 STANDARD COVERSHEET

2035

Instrument Flight Control Branch
Chanute AFB, Illinois

3ABR32531-HO-404
3ABR32632B-HO-504

FLIGHT DIRECTOR SYSTEM
(MODES OF OPERATION)

This handout was prepared for use in the 3ABR32531, Avionics Instrument Systems Specialist Course and in the 3ABR32632B, Integrated Avionic Systems Specialist Course. It is designed to be issued to the student and used in conjunction with 3ABR32531-PT-404 (3ABR32632B-PT-504), Flight Director System.

Supersedes 3ABR32531-HO-405, 25 February 1974.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC/W - 200; TTVSR - 1

2130

ISC MODE SELECTOR KNOB POSITIONS VS ADI INDICATIONS

ISC MODE SELECTOR KNOB POSITIONS

	OFF	ILS	AILA	TACAN	CRS SEL NAV	BOMB/ NAV	CRS LINE	MAN CRS	MAN HDG	TKR/ RV
Bank Steering Bar	Out of View	Steer to Loc	Com steer fr B/N to set crs	Steer to TACAN crs	Com steer fr B/N to set crs	Com steer to dest	Com steer to crs line	Com steer to selected crs	Hdg fr HSI & FDC	Target steer fr attack radar
Pitch Steering Bar	Out of View	In view in alt ref & when G/S beam inter		Out of view unless TF or ALT REF is selected						Target elev fr attack radar
Heading Reference Scale	Mag hdg from B/N or mag hdg from AFRS if pri hdg caution lamp is on, or mode selector knob is in TACAN or TKR RV.									
Attitude Sphere	Pitch and roll from B/N system when selected, or from the AFRS when pri/att/hdg caution light is ON, or AUX is selected.									
Glide Slope Indicator	Out of View	G/S fr G/S rec	Dev fr set G/S fr B/N	——— Out of View ———						
Course Warning Flag	Out of View	Out of view when loc adeq sig stren	Out of view loc valid fr B/N	Out of view when TACAN adeq sig stren	Out of view when lateral steering is valid fr B/N				Out of view when man hdg valid	Out of view
Glide Slope Warning Flag	Out of View	Out of view when G/S adeq sig stren	Out of view when dev fr G/S is valid	——— Out of View ———						
Attitude Warning Flag	Normal condition - Out of view. Abnormal condition - In view, disregard ADI and use stby att ind or ODS for attitude and glide slope.									
ISC Pitch Steer Sw	TF or ALT REF	Off when G/S is intercepted			TF or ALT REF					Not Useable

Note: ALT REF is useable prior to intercepting G/S. When G/S is intercepted the ALT REF is automatically disengaged by the FDC in ILS or B/N in AILA mode.

2037

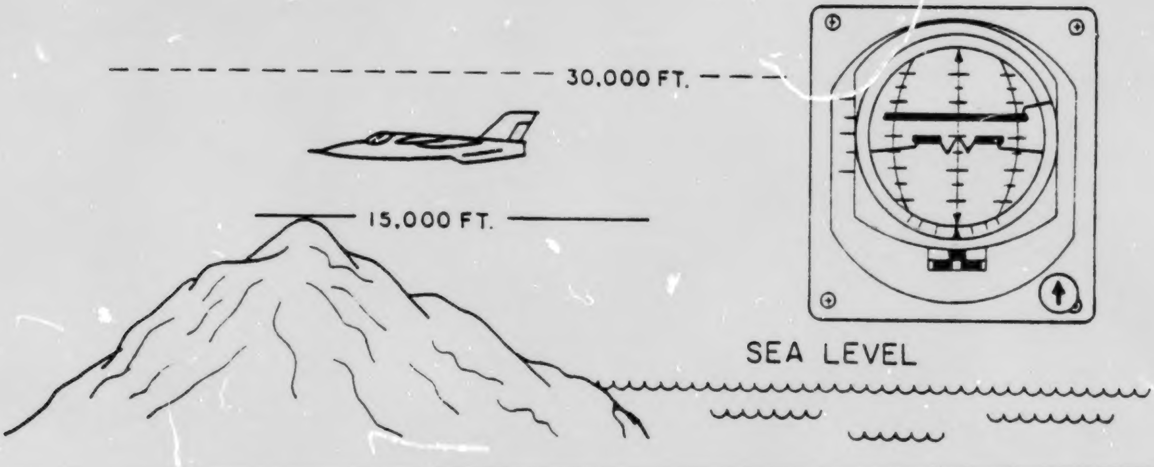
ISC MODE SELECTOR KNOB POSITIONS VS HSI INDICATIONS

ISC MODE SELECTOR KNOB POSITIONS

	OFF	ILS	AILA	TACAN	CRS SEL NAV	BOMB/NAV	CRS LINE	MAN CRS	MAN HDG	TKR RV
Course Set Knob	Not Used	Used to set ldg approach crs in crs set window		Used to set Tacan crs	Used to set desired crs	Not used	Not used	Used to set des crs	Not used	
Heading Set Knob	——— Not Used ———								Used to set desired mag hdg	Not used
Compass Card	Heading fr B/N sys when sel, or mag hdg fr the AFRS when pri hdg caution light is ON or AUX is sel, excpt TACAN or TKR RV modes which uses AFR mag hdg only									
Course Select Window & Course Arrow	Mag grd track fr B/N	Ldg approach crs man set by the crs set knb		TACAN crs man set	Desired crs man set	Cur gnd trk	Cur grd trk	Fix at last set pos	Ground track from B/N	
Course Deviation Indicator	Not used ctr	Loc dev fr loc rec	Loc dev fr B/N	TACAN dev fr sel crs	Lateral dev fr B/N				Not used—Center	
Heading Marker	Indicates computed course from B/N								Mag hdg man set	Bearing to tkr fr attack radar
Course Deviation Bar Flag	Out of view			Out of view by TACAN	Out of view by B/N				Out of view by FDC	
Power Off Warning Flag	Normal condition—Out of view Abnormal Condition— When in view, disregard HSI and ADI in MAN/HDG mode and use BDHI									
Range Ind and Warning Flag	Indicates distance to TACAN station									
Bearing Pointer (TACAN)	Indicates bearing to TACAN station									
To-From Indicator (TACAN)	Out of view—Not used			To or from TACAN		Out of view— Not used				

ALTITUDE REFERENCE

2038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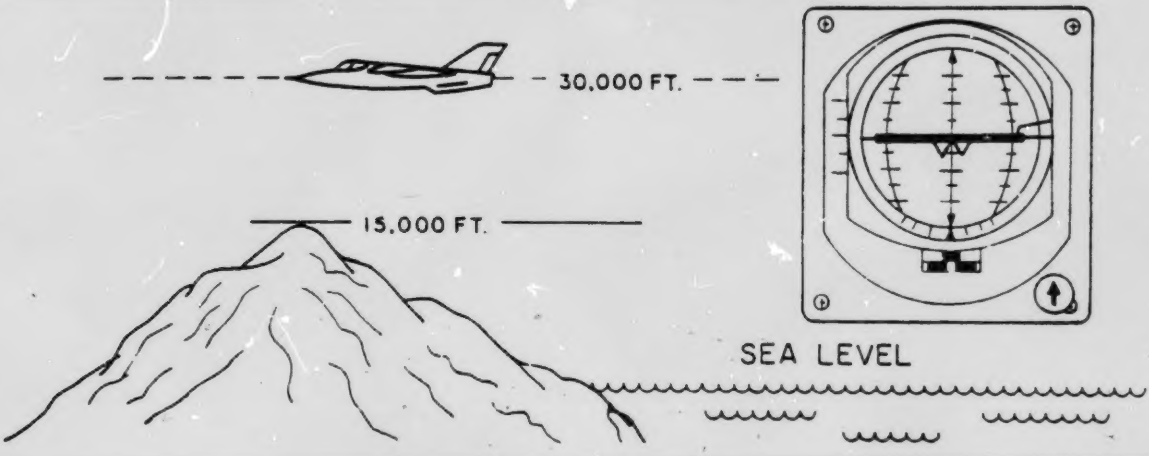
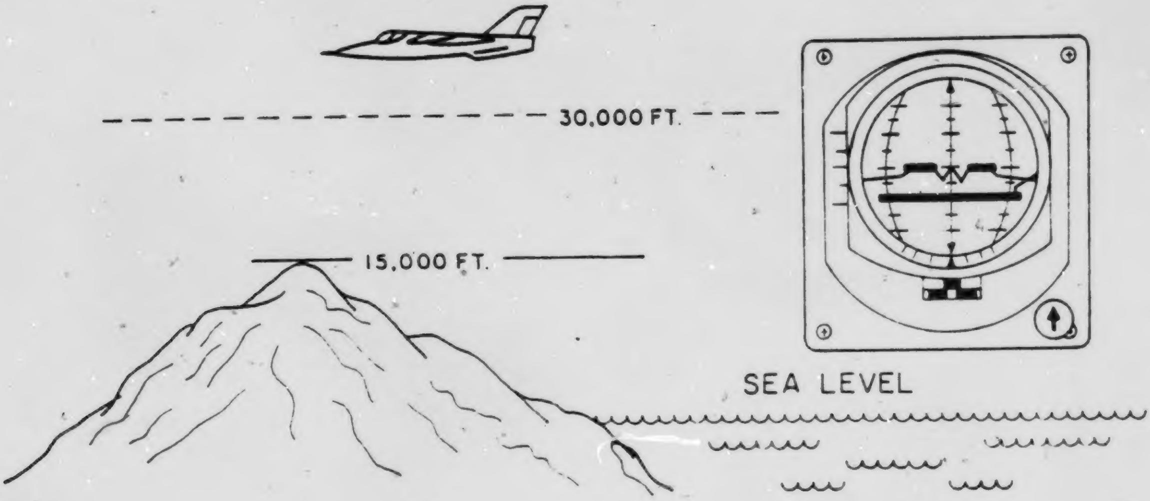
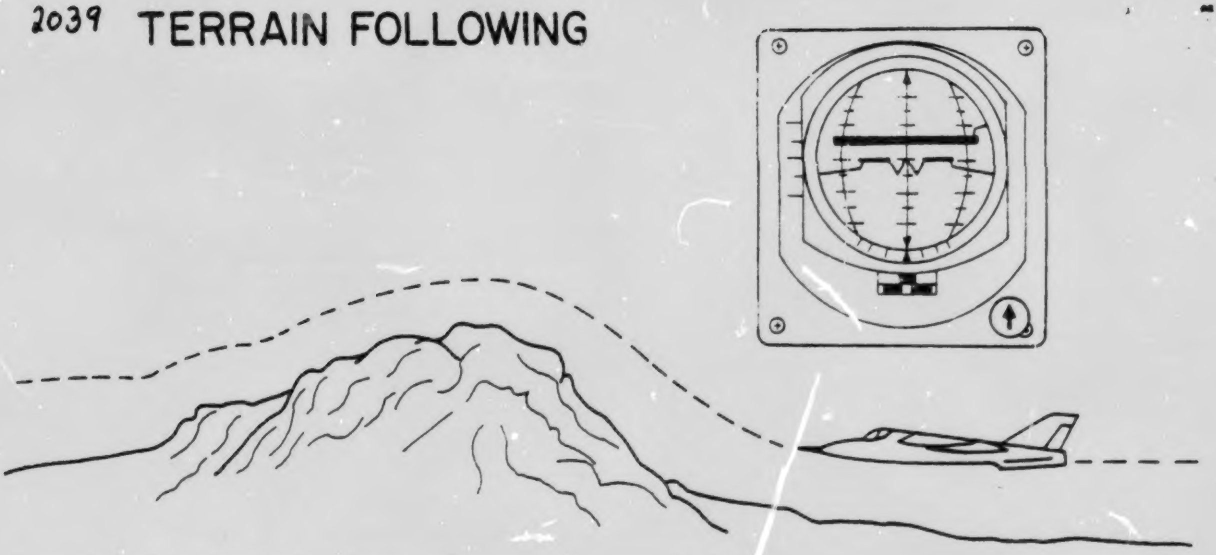
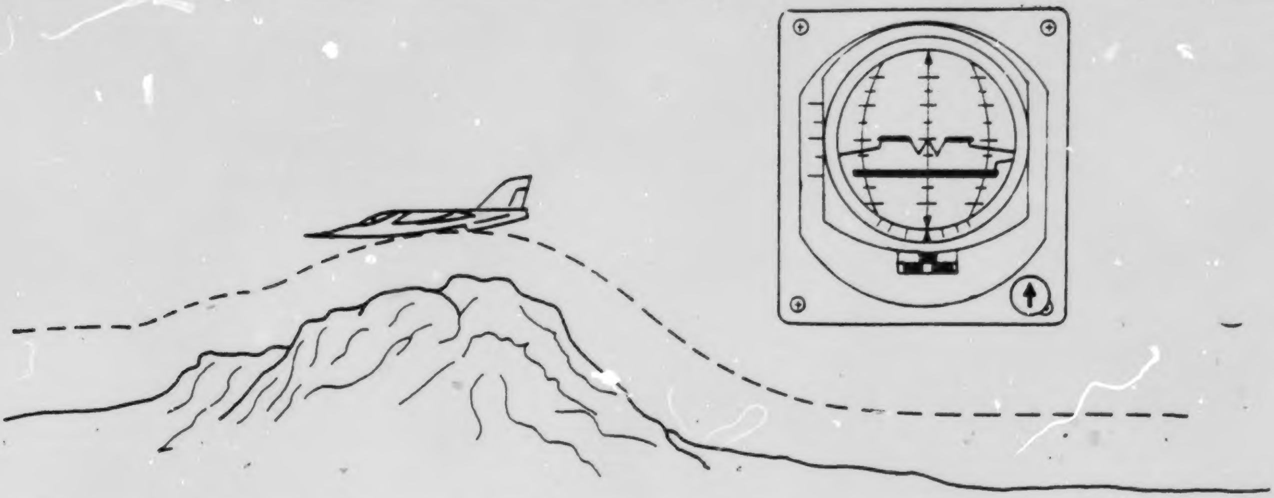
15,000 FT.
SEA LEVEL

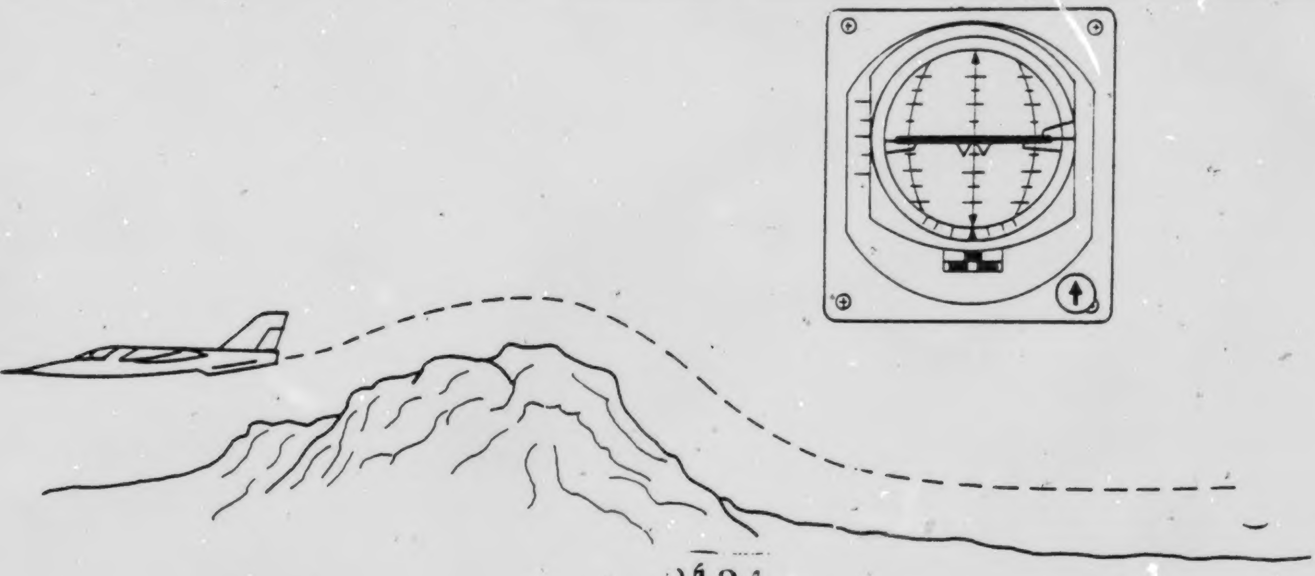

30,000 FT.
15,000 FT.
SEA LEVEL

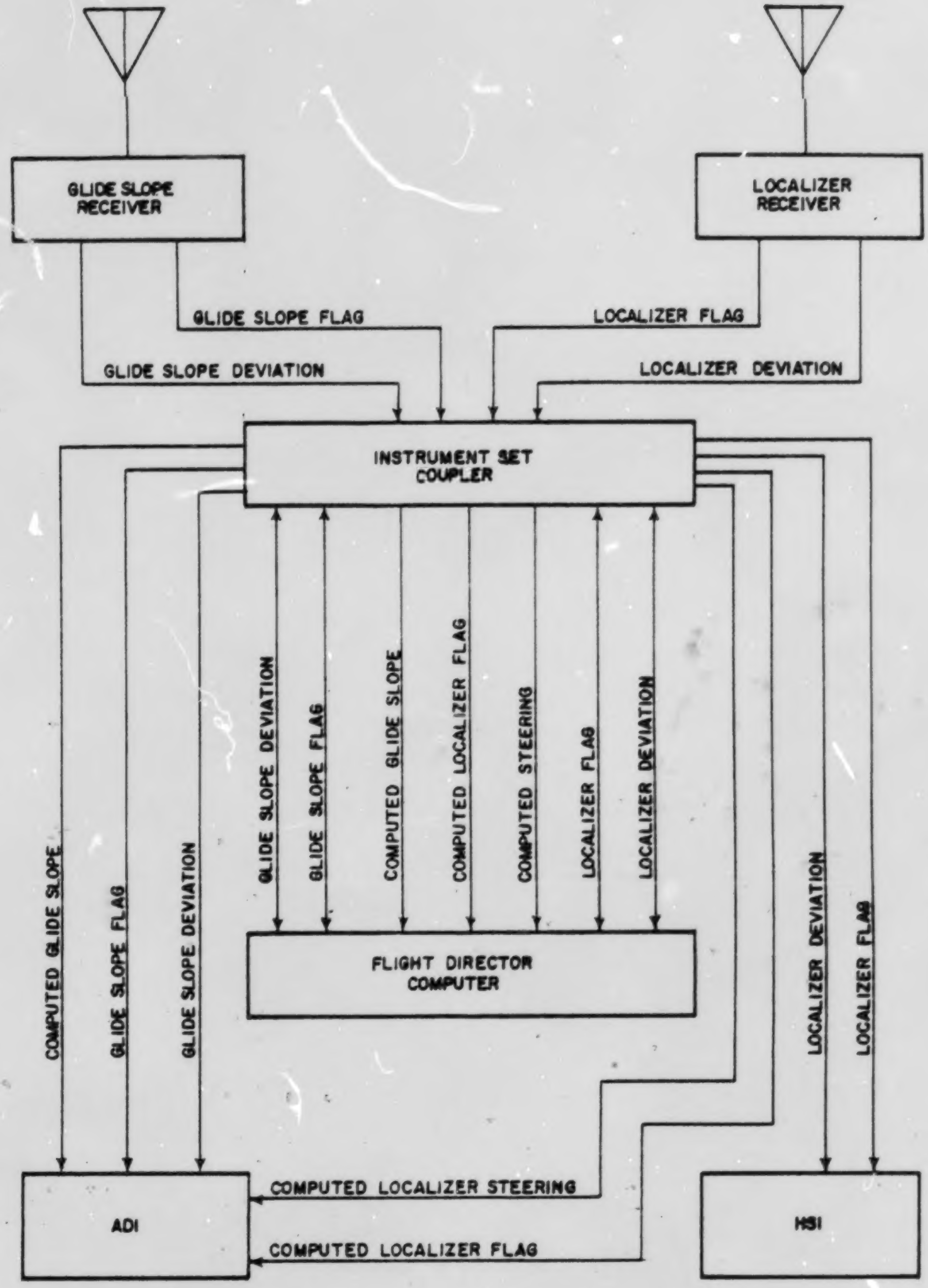

30,000 FT.
15,000 FT.
SEA LEVEL

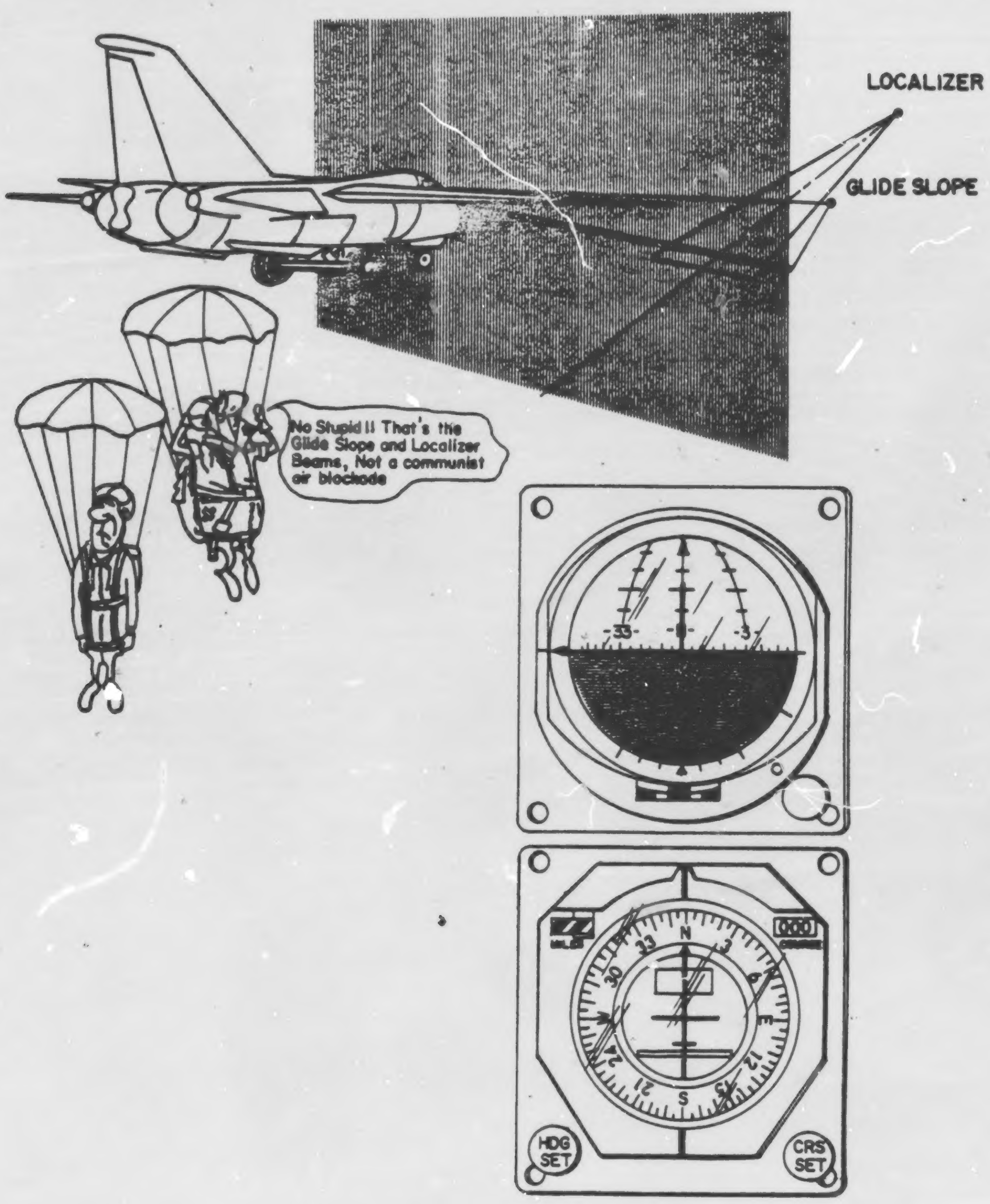
2039 TERRAIN FOLLOWING

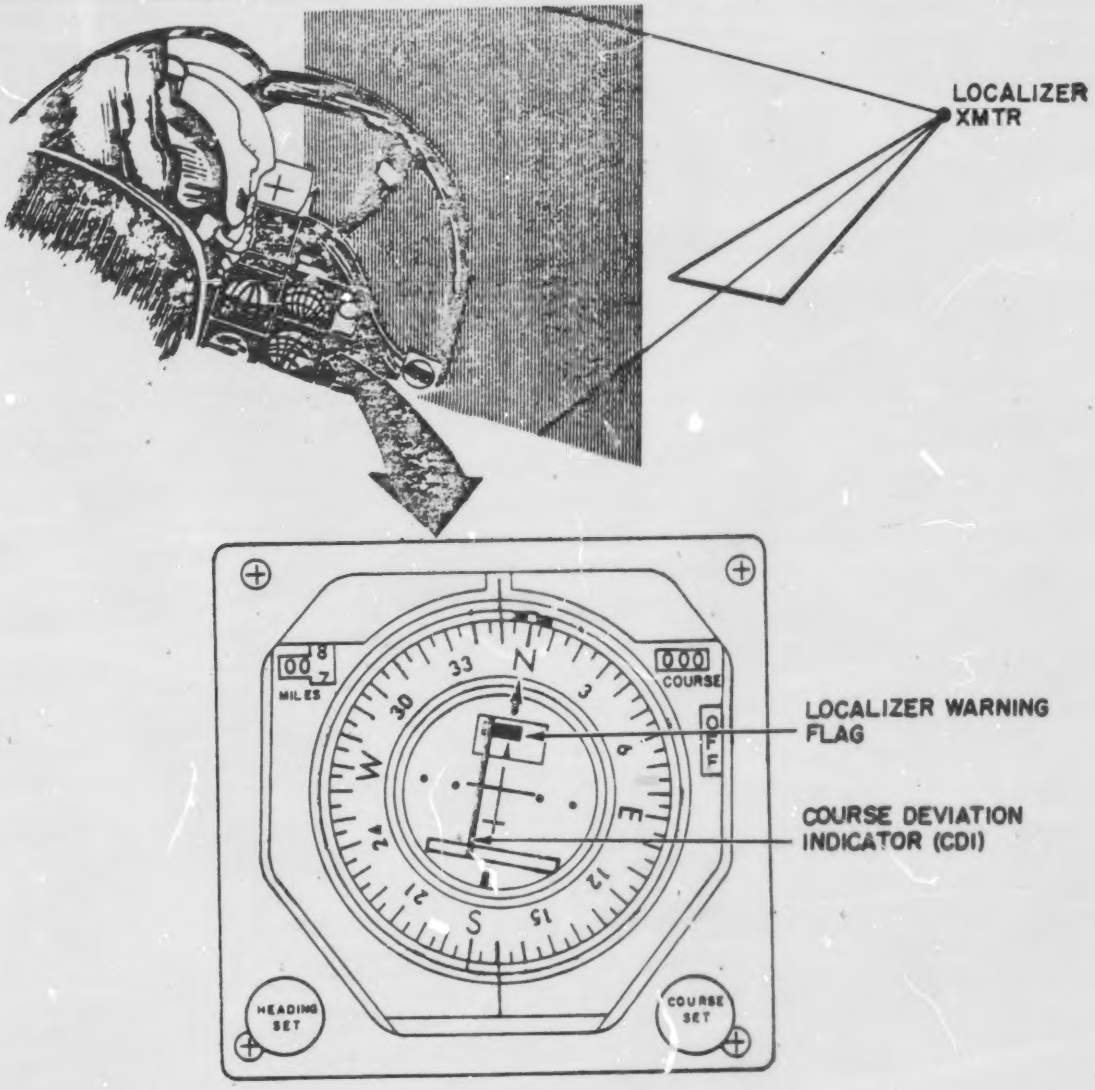




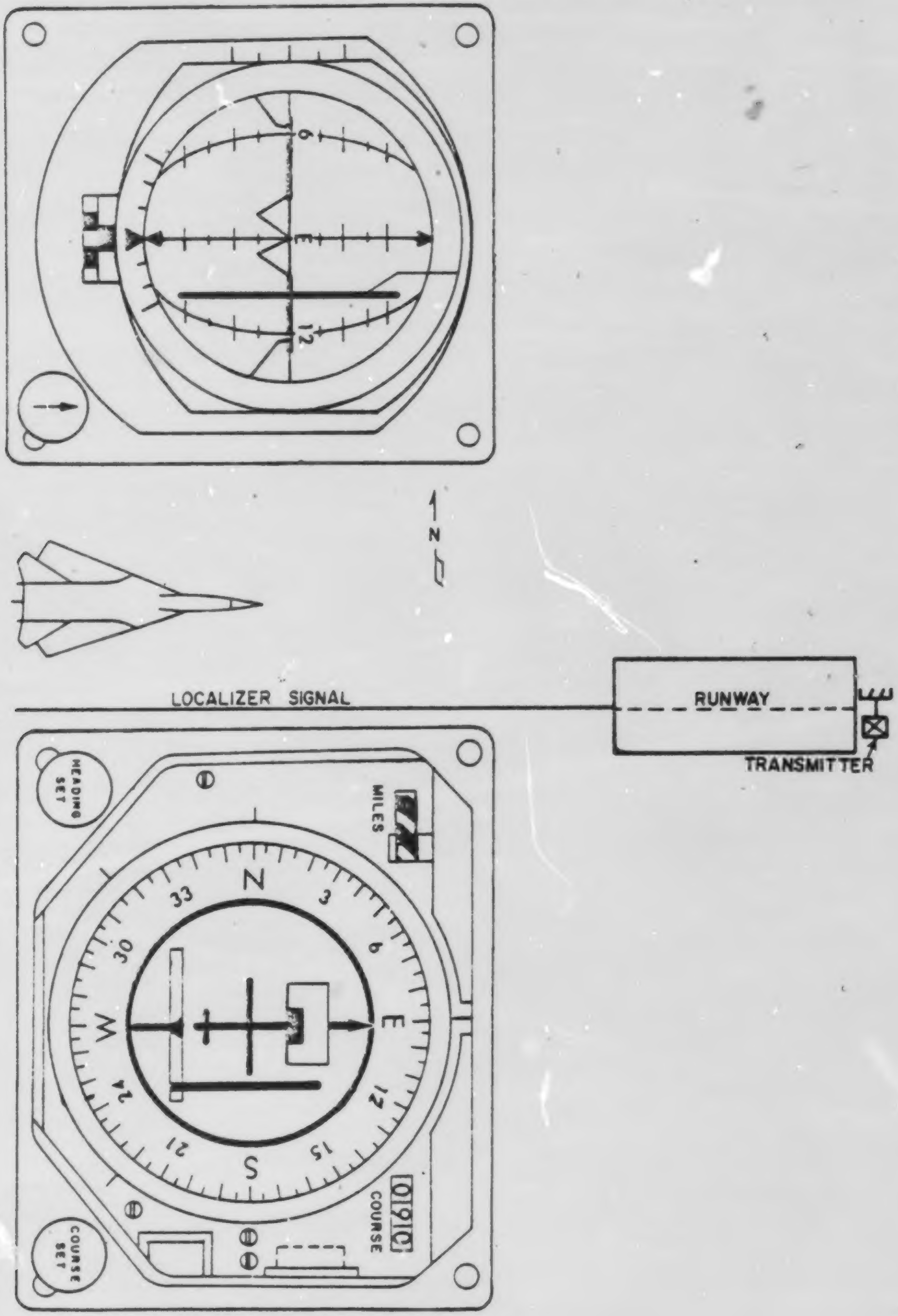


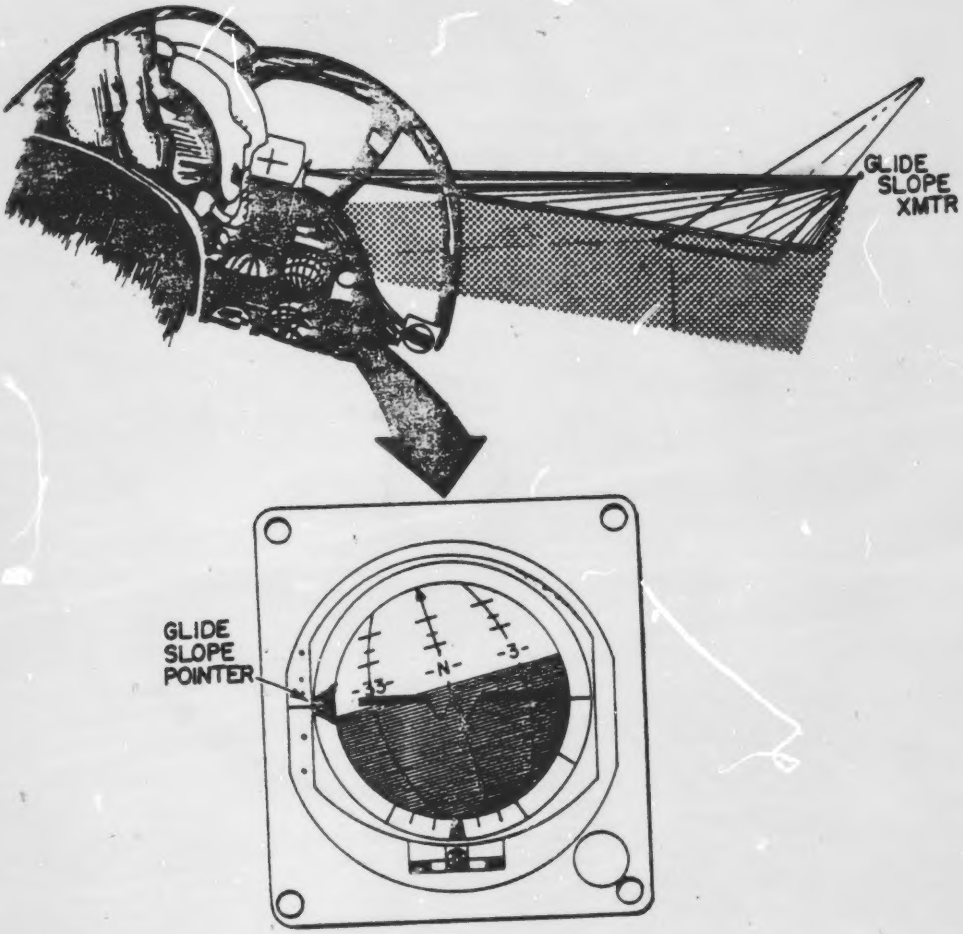

GLIDE SLOPE RECEIVER
LOCALIZER RECEIVER
GLIDE SLOPE FLAG
LOCALIZER FLAG
GLIDE SLOPE DEVIATION
LOCALIZER DEVIATION
INSTRUMENT SET COUPLER
COMPUTED GLIDE SLOPE
GLIDE SLOPE FLAG
GLIDE SLOPE DEVIATION
GLIDE SLOPE DEVIATION
GLIDE SLOPE FLAG
COMPUTED GLIDE SLOPE
COMPUTED LOCALIZER FLAG
COMPUTED STEERING
LOCALIZER FLAG
LOCALIZER DEVIATION
LOCALIZER DEVIATION
LOCALIZER FLAG
FLIGHT DIRECTOR COMPUTER
ADI
COMPUTED LOCALIZER STEERING
COMPUTED LOCALIZER FLAG
HSI


LOCALIZER
GLIDE SLOPE
No Stupid!! That's the Glide Slope and Localizer Beams, Not a communist air blockade
-33-
-3-
N
33
3
30
6
E
24
21
S
15
12
HDG SET
CRS SET

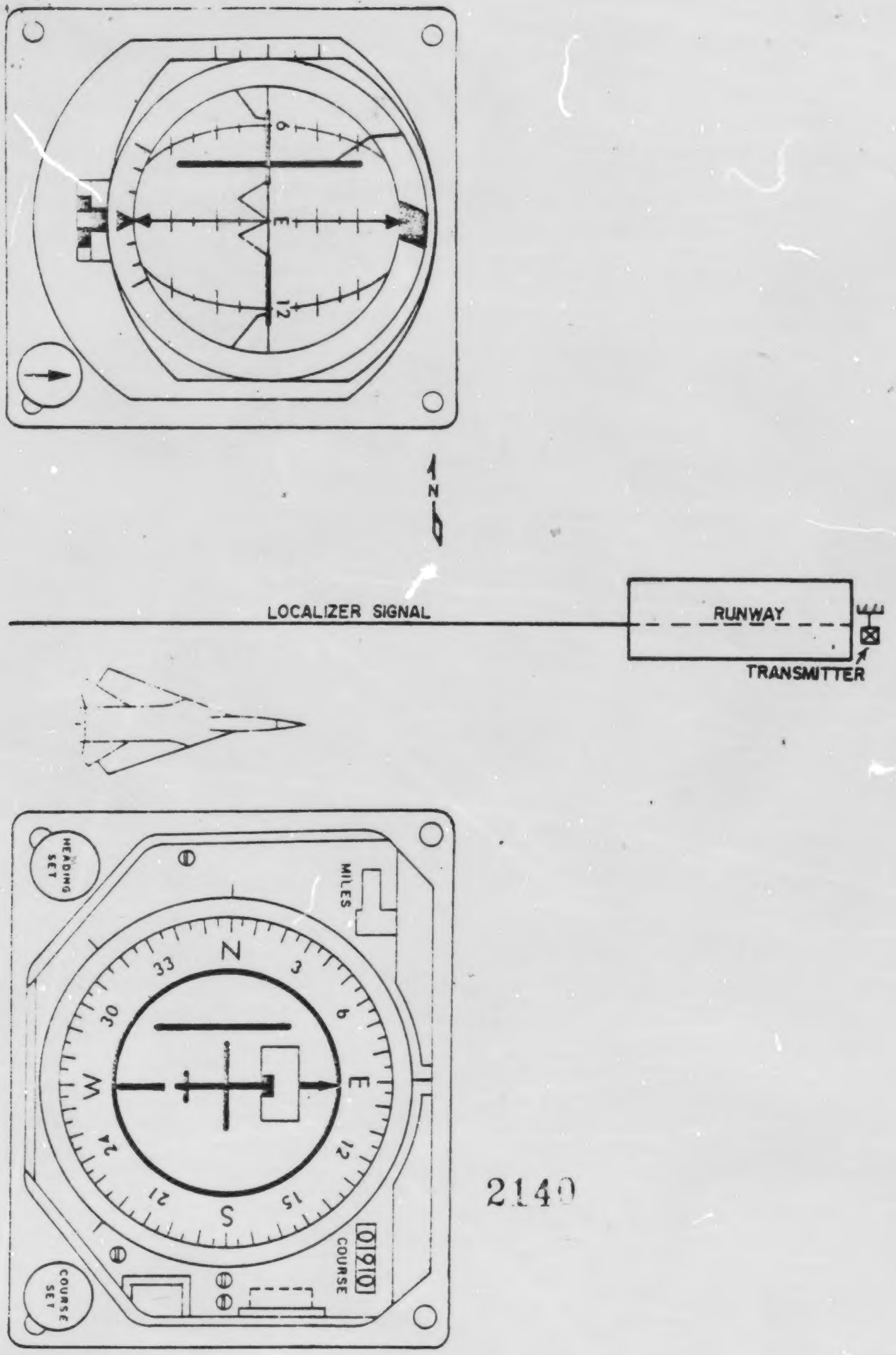


LOCALIZER XMTR
LOCALIZER WARNING FLAG
COURSE DEVIATION INDICATOR (CDI)
00 8 7
MILES
000
COURSE
OFF
N
3
6
E
12
15
S
21
24
W
30
33
HEADING SET
COURSE SET

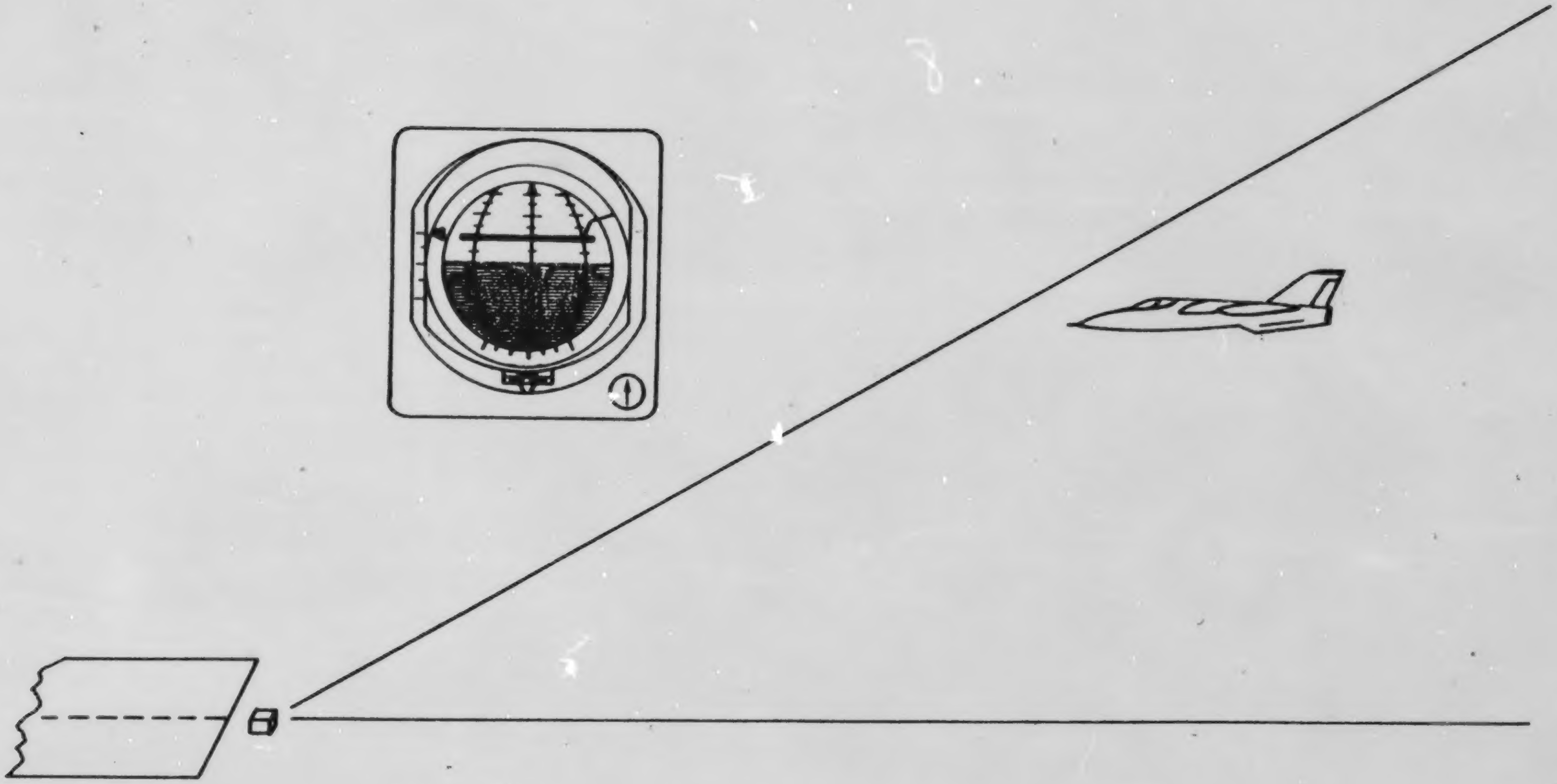

6
E
12
N
LOCALIZER SIGNAL
RUNWAY
TRANSMITTER
HEADING SET
MILES
N
33
3
30
6
W
E
24
12
21
15
S
019 0
COURSE
COURSE SET

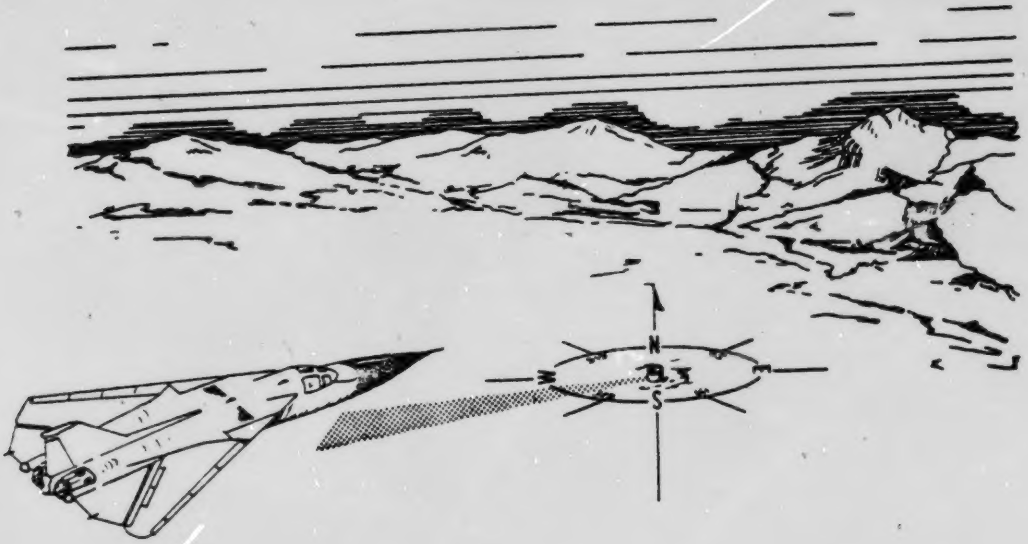

GLIDE SLOPE XMTR
GLIDE SLOPE POINTER
-33-
-N-
-3-

2045

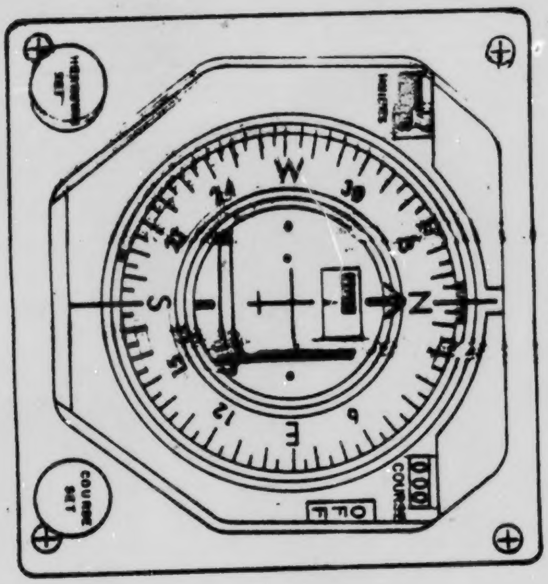

6
E
12
N
LOCALIZER SIGNAL
RUNWAY
TRANSMITTER
HEADING SET
MILES
N
33
3
30
6
W
E
24
12
21
S
15
0 9 0
COURSE
COURSE SET

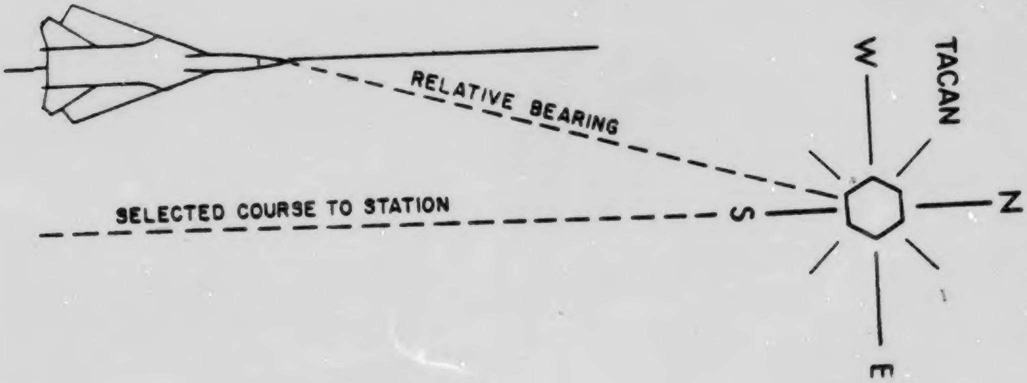
2140



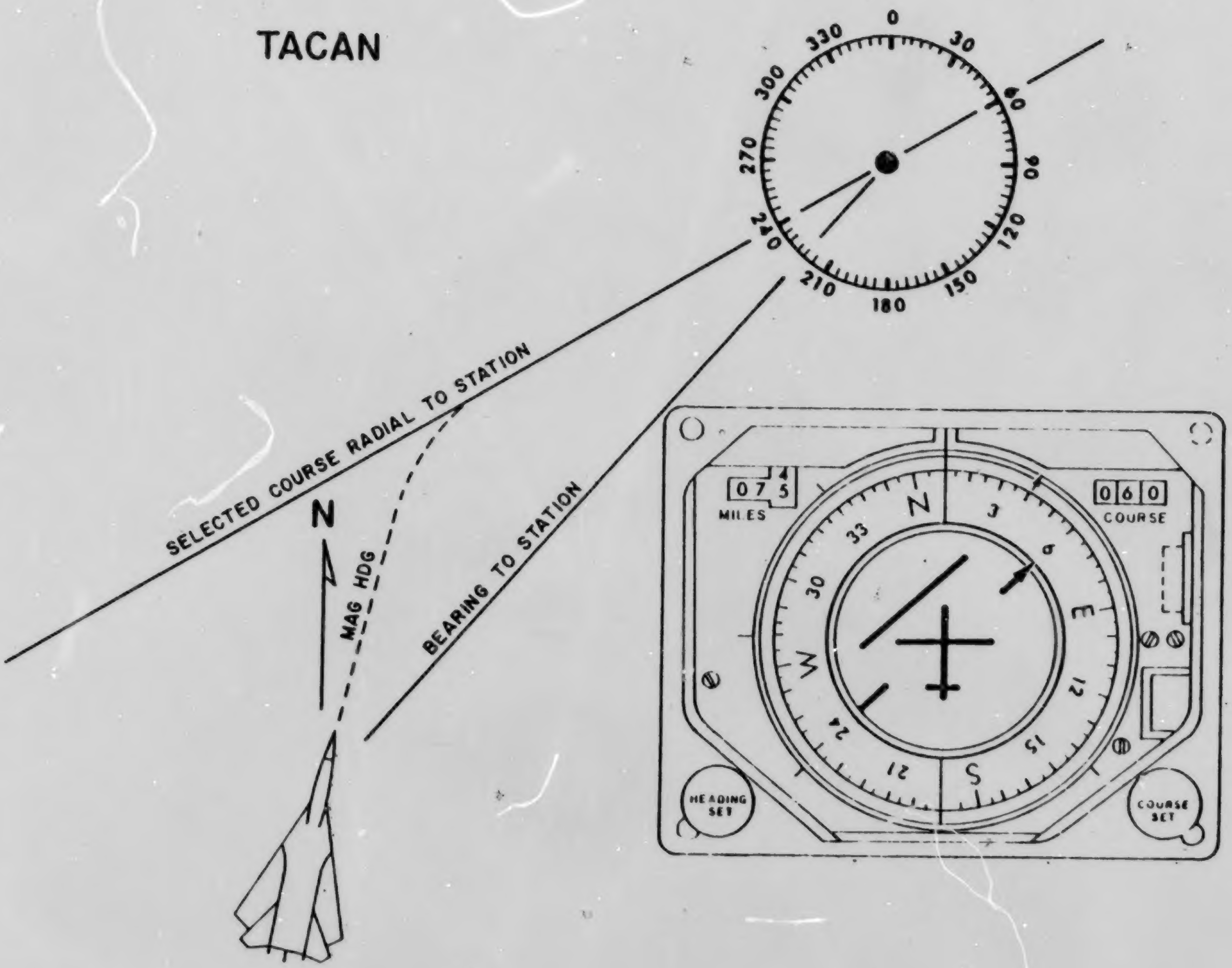


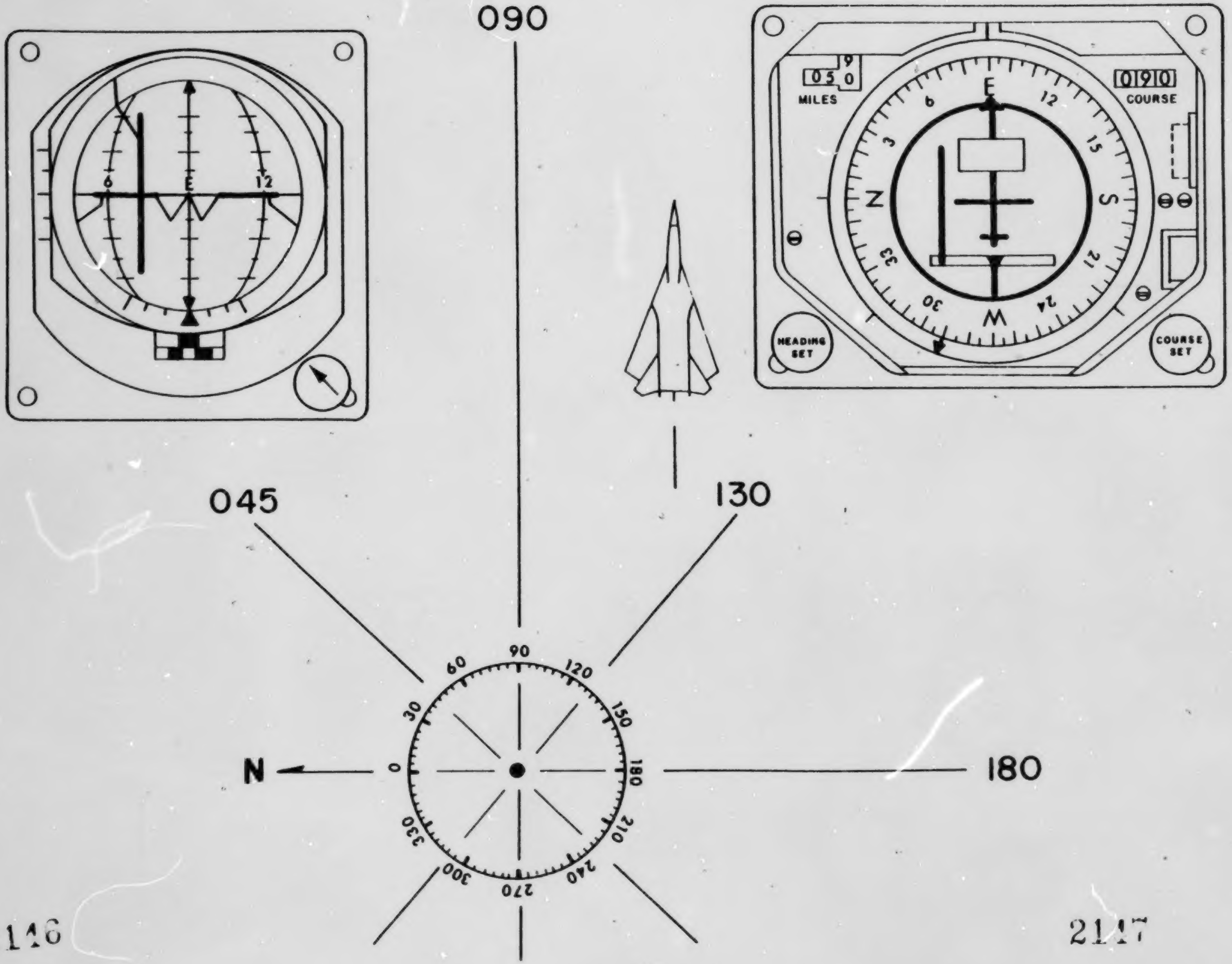
2143


HEADING SET
MILES
W
30
33
N
3
6
E
12
15
S
21
24
COURSE
000
OFF
COURSE SET


RELATIVE BEARING
SELECTED COURSE TO STATION
TACAN
W
N
S
E

TACAN


SELECTED COURSE RADIAL TO STATION
BEARING TO STATION
N
MAG HDG
0 7 5
MILES
0 6 0
COURSE
N
E
S
W
HEADING SET
COURSE SET

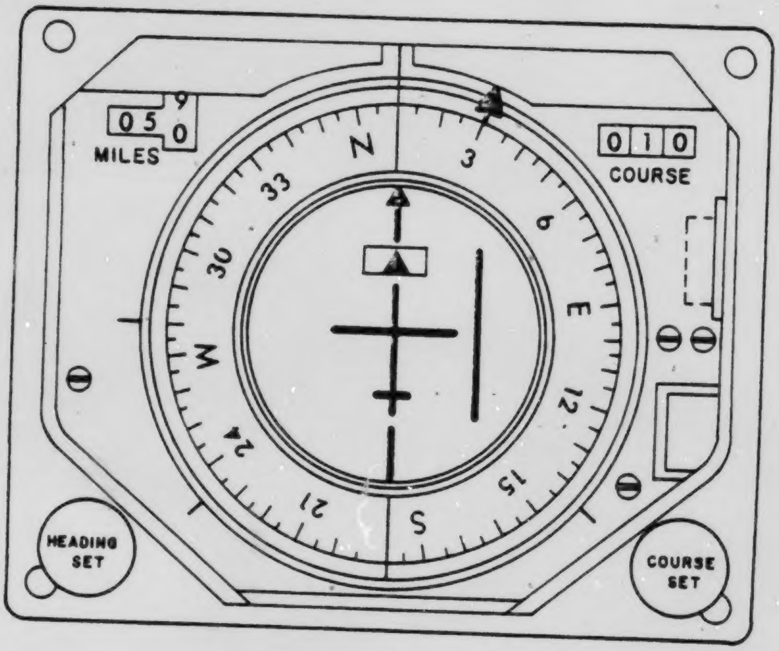

6
E
12
090
045
130
180
N
0
30
60
90
120
150
180
210
240
270
300
330
0 5
9
0
MILES
0 9 0
COURSE
E
6
12
3
15
N
S
33
21
30
24
W
HEADING SET
COURSE SET

2146

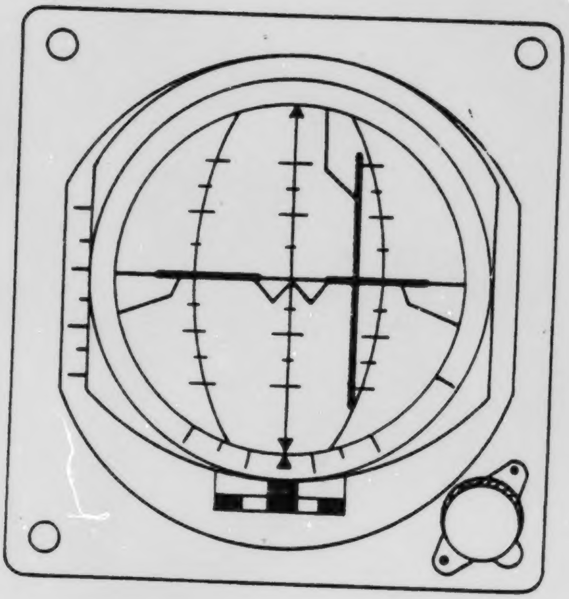
2147

2050

2051

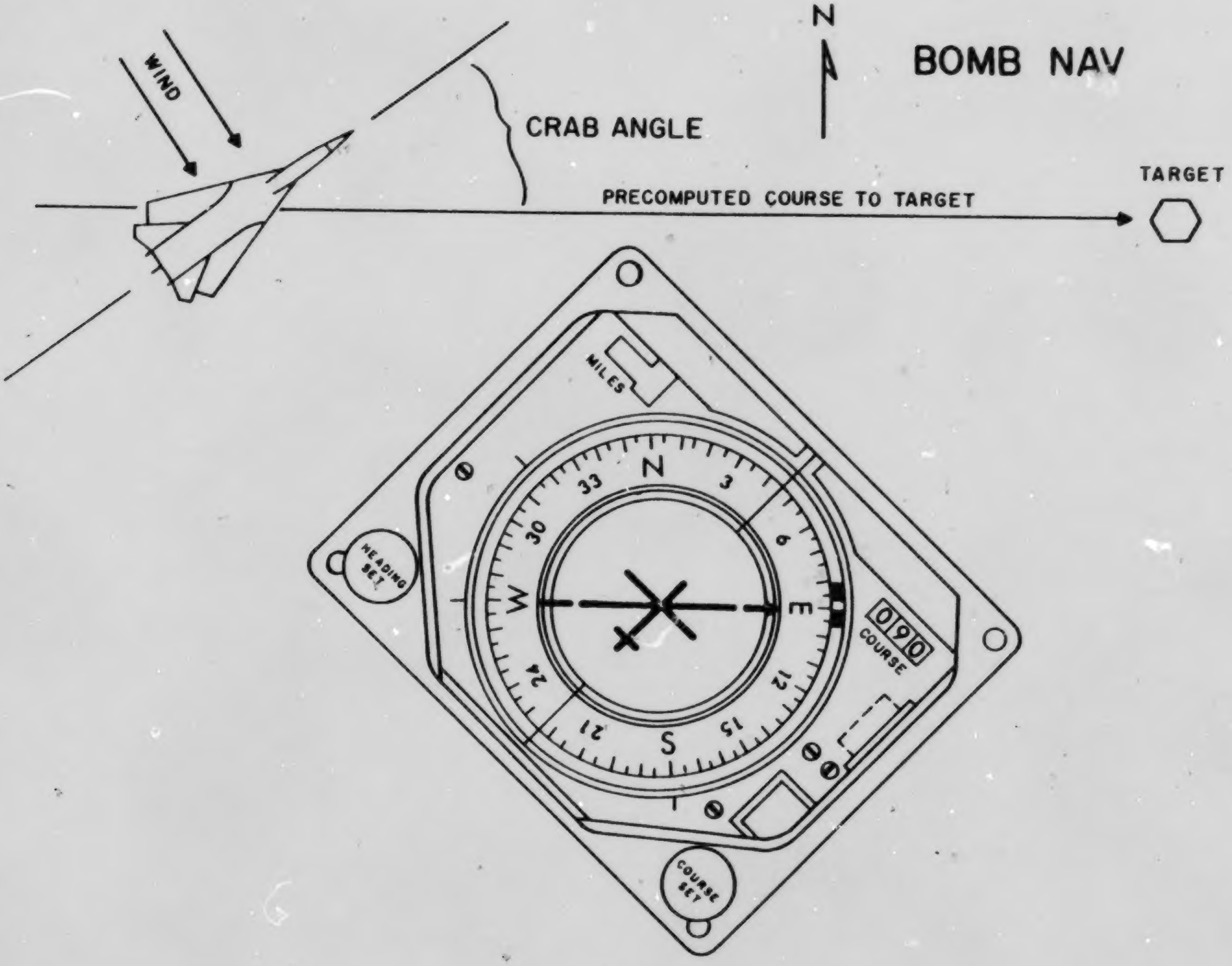

0 5
9
0
MILES
N
3
33
6
30
E
W
12
24
15
21
S
0 1 0
COURSE
HEADING SET
COURSE SET

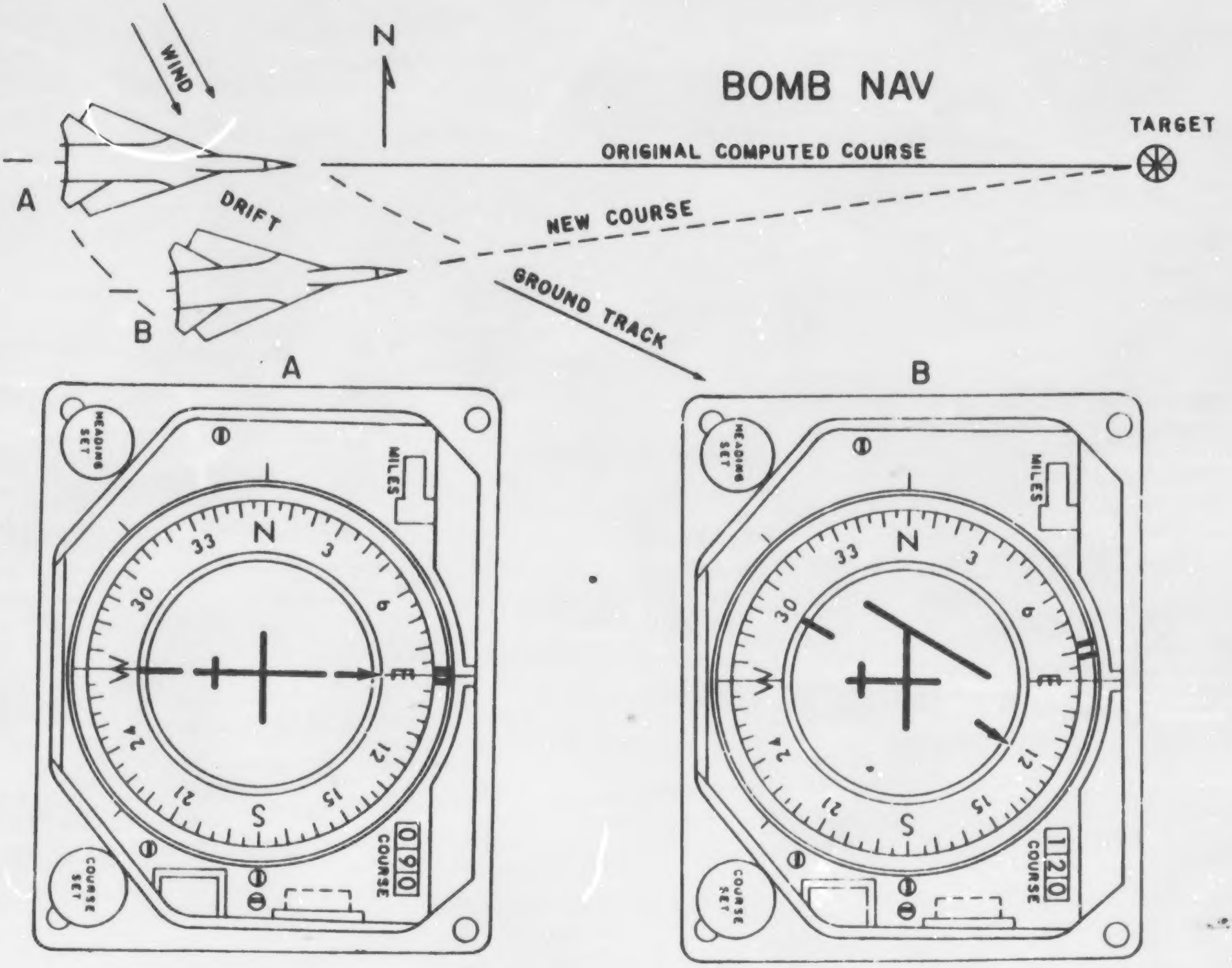
HSI



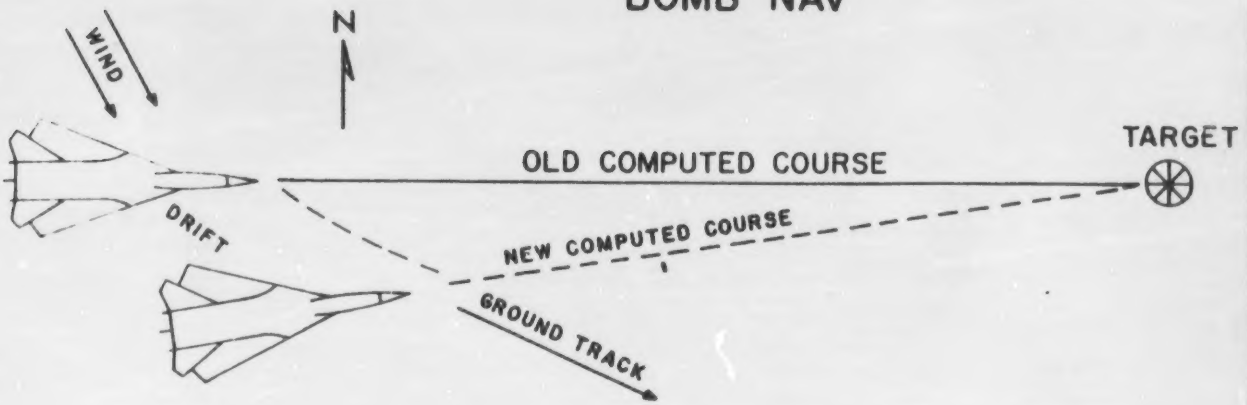
ADI

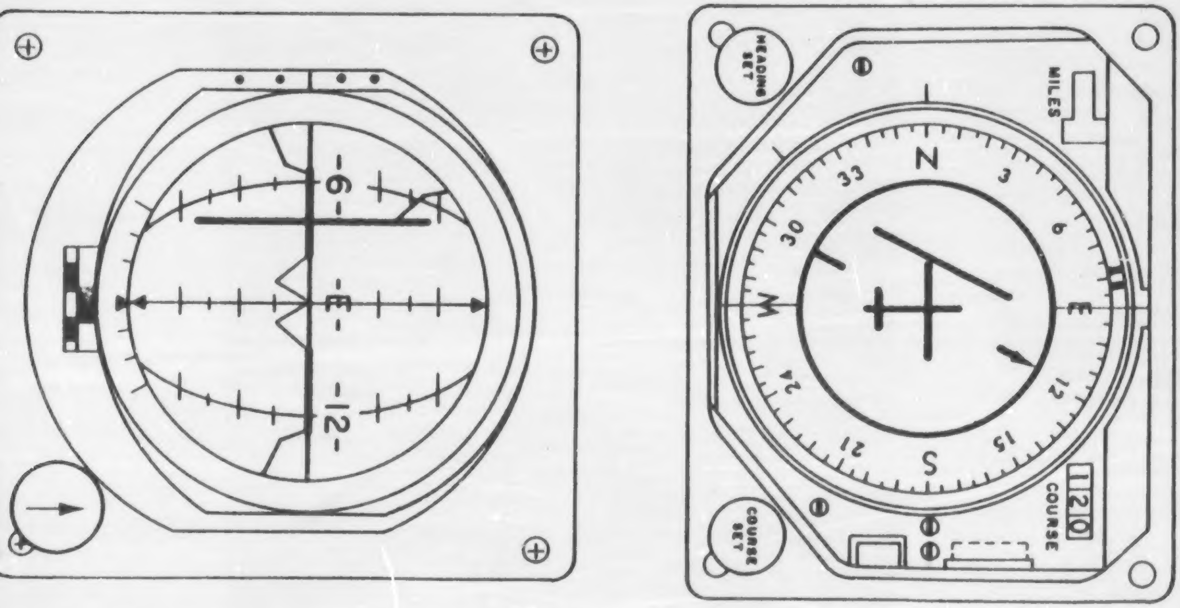
2118


WIND
CRAB ANGLE
N
BOMB NAV
PRECOMPUTED COURSE TO TARGET
TARGET
MILES
HEADING SET
N
3
6
E
12
15
S
21
24
W
30
33
090
COURSE
COURSE SET

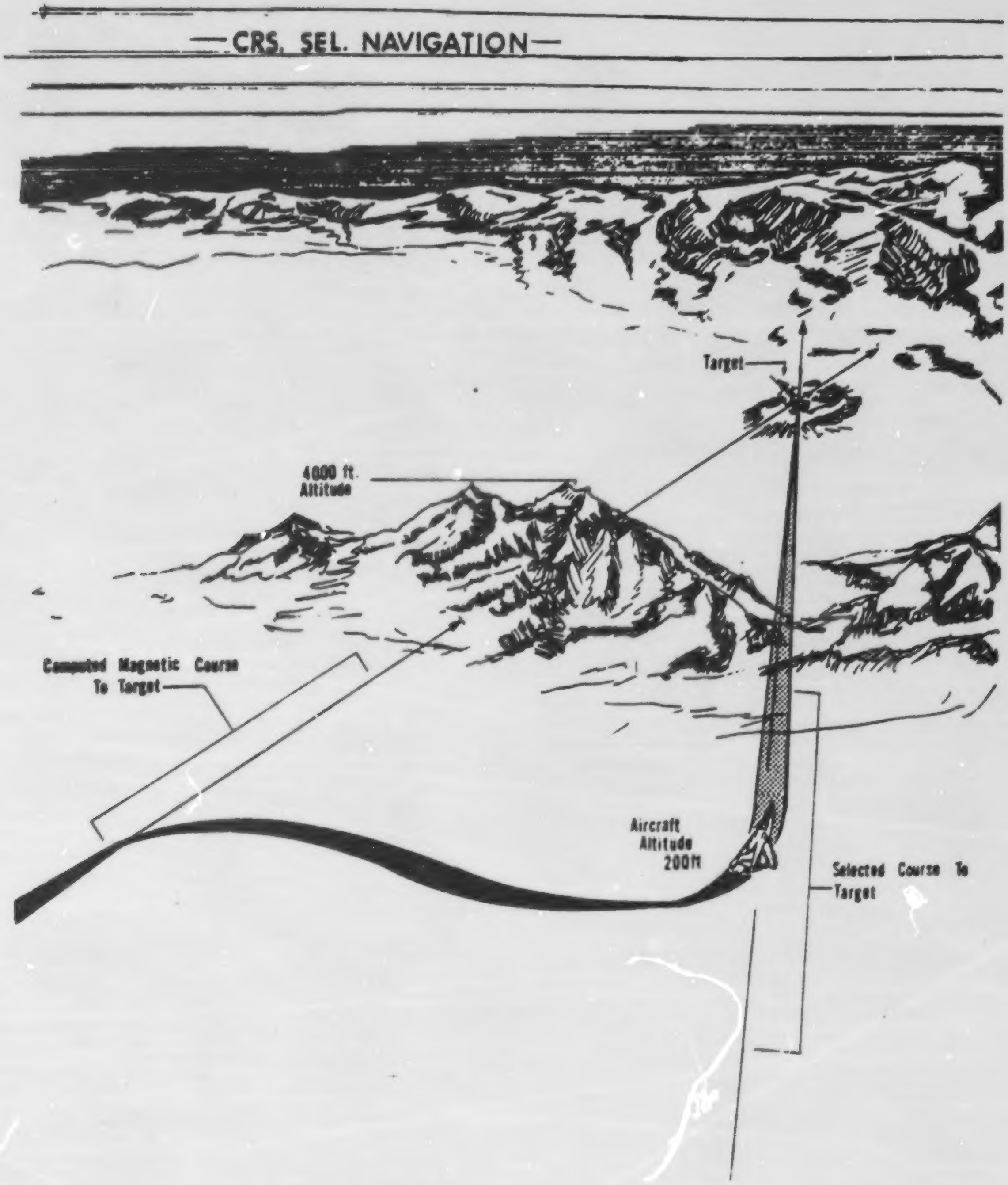

WIND
N
BOMB NAV
TARGET
ORIGINAL COMPUTED COURSE
A
DRIFT
NEW COURSE
B
GROUND TRACK
A
B
HEADING SET
MILES
N
3
6
E
12
15
S
21
24
W
30
33
COURSE SET
COURSE
090
120

BOMB NAV


WIND
N
TARGET
OLD COMPUTED COURSE
DRIFT
NEW COMPUTED COURSE
GROUND TRACK


-6-
-E-
-12-
HEADING SET
MILES
N
33
3
30
6
W
E
24
12
21
15
S
120
COURSE
COURSE SET

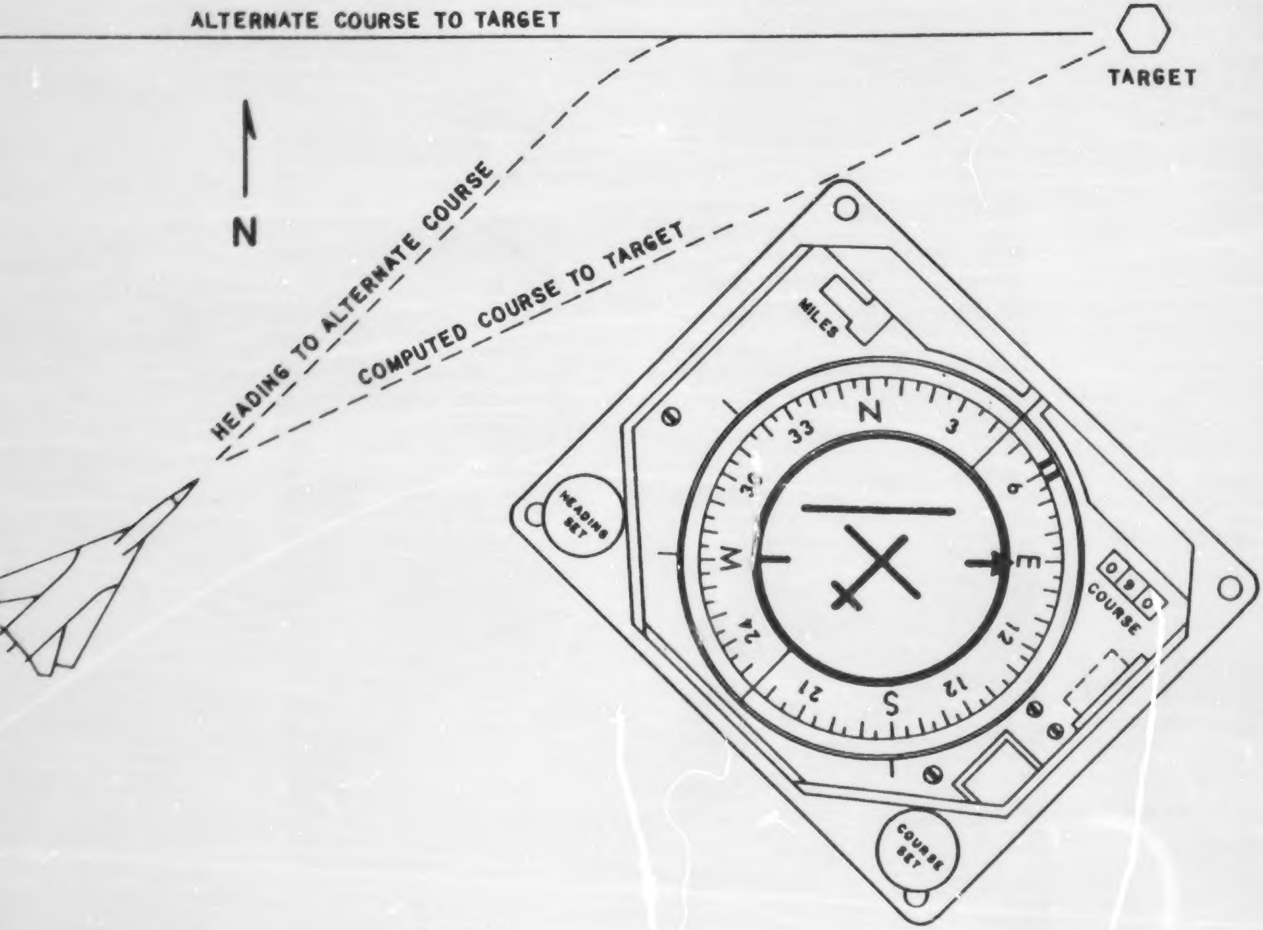
2055

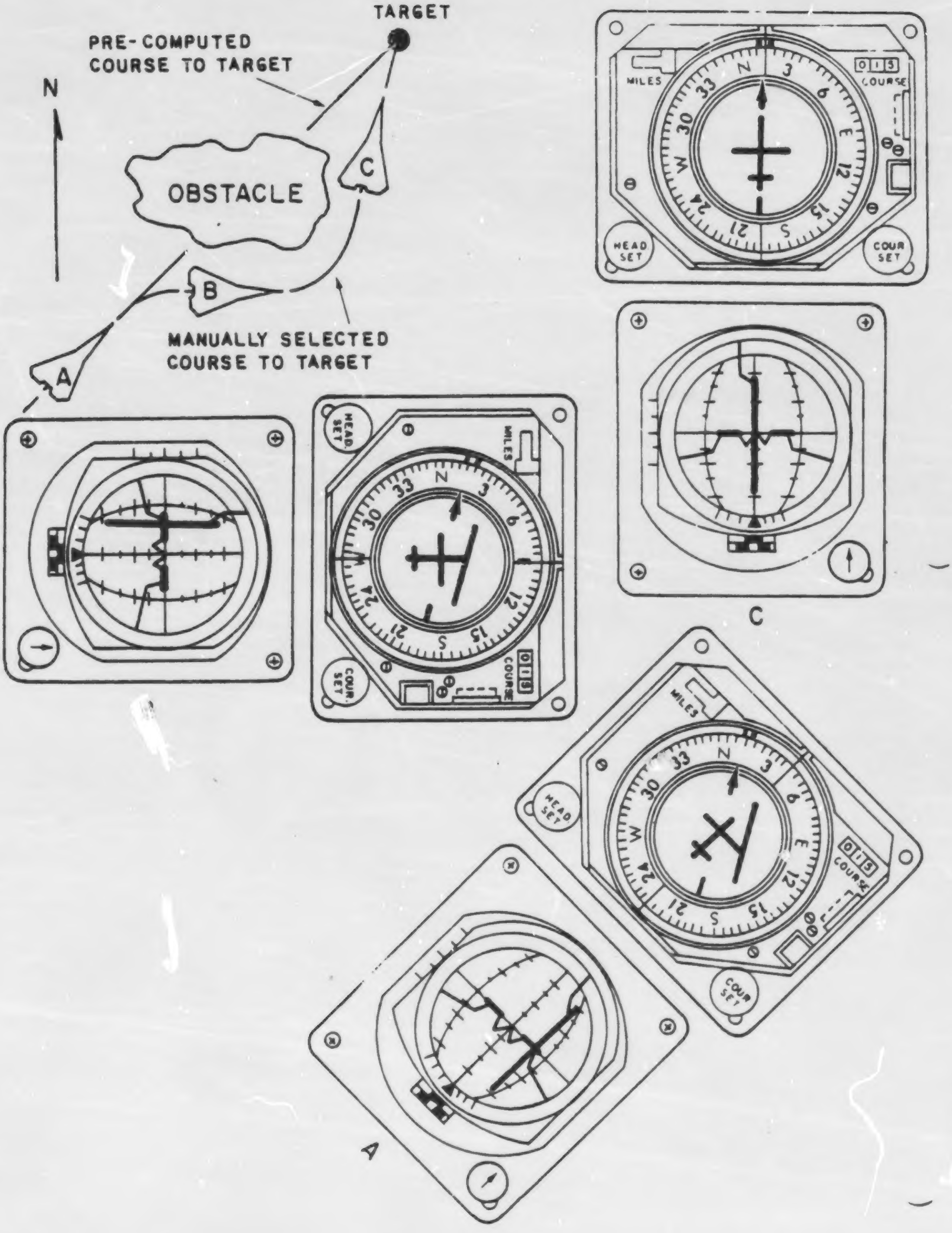


—CRS. SEL. NAVIGATION—

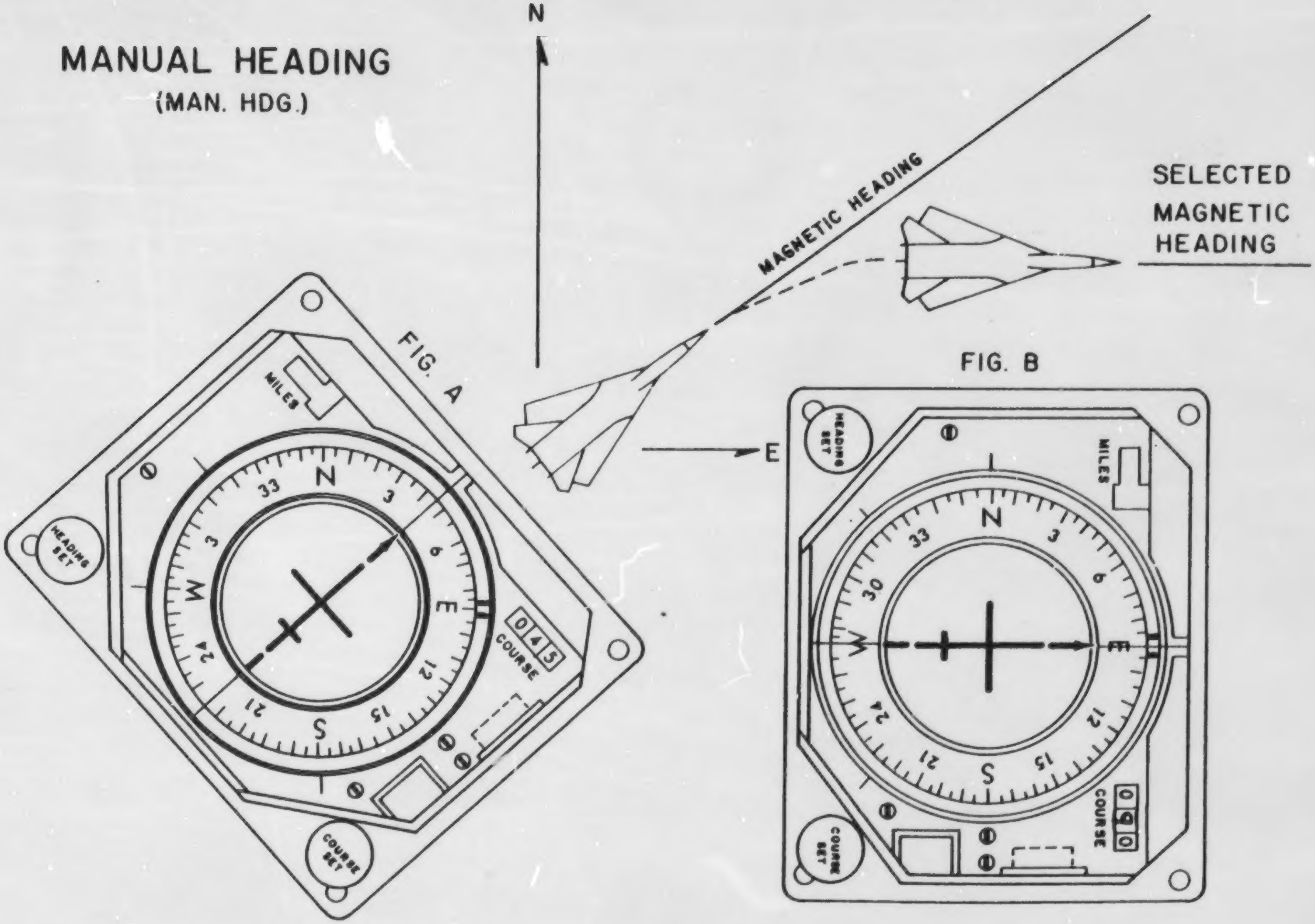
Target
4000 ft.
Altitude
Computed Magnetic Course
To Target
Aircraft
Altitude
200ft
Selected Course To
Target

COURSE SELECT NAVIGATION


ALTERNATE COURSE TO TARGET
TARGET
N
HEADING TO ALTERNATE COURSE
COMPUTED COURSE TO TARGET
MILES
HEADING SET
N
3
6
E
12
S
21
24
W
30
33
COURSE
0 9 0
COURSE SET

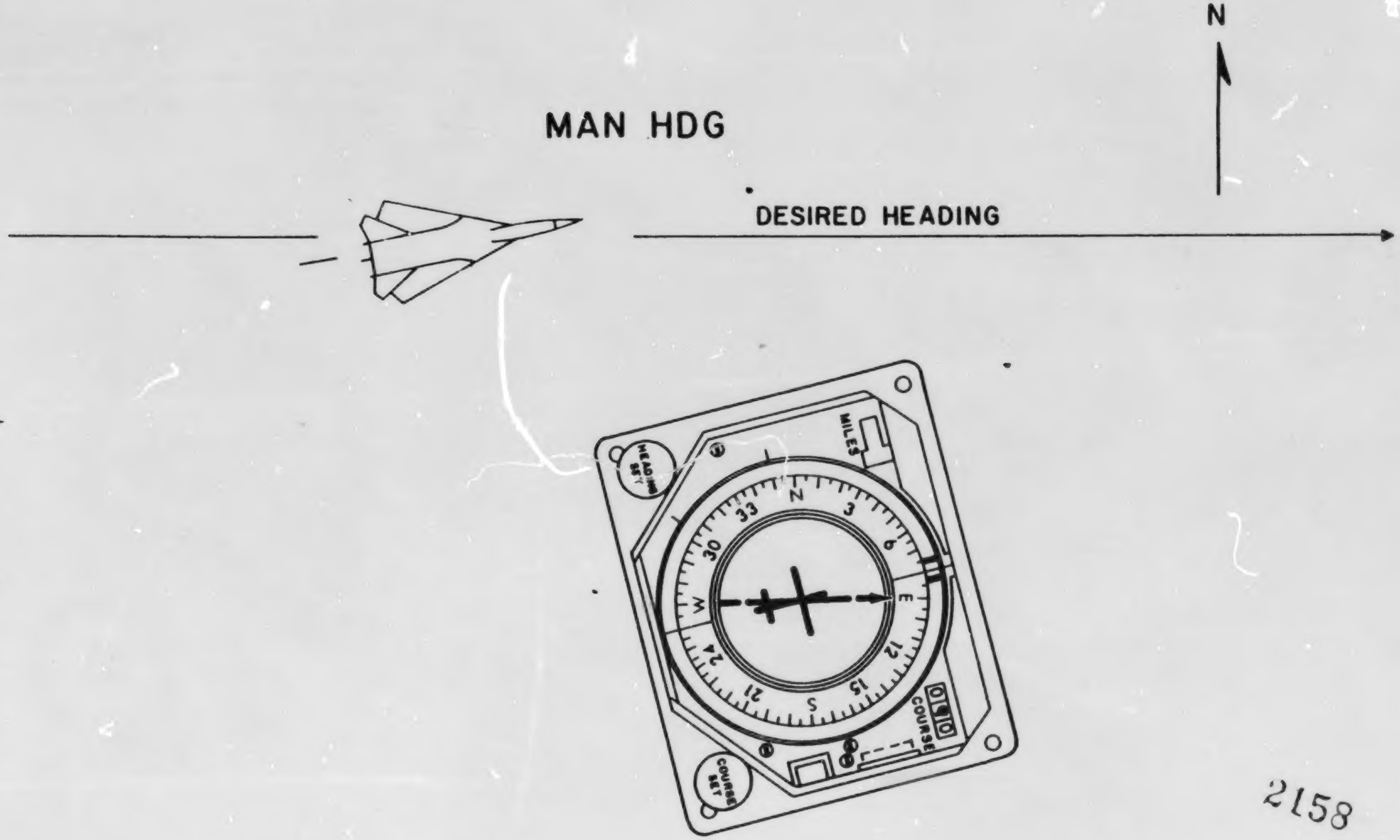

TARGET
PRE-COMPUTED COURSE TO TARGET
N
OBSTACLE
A
B
C
MANUALLY SELECTED COURSE TO TARGET
MILES
0 1 5
COURSE
N
3
6
E
12
15
S
21
24
W
30
33
HEAD SET
COUR SET
0 1 9
C
A

MANUAL HEADING
(MAN. HDG.)


N
MAGNETIC HEADING
SELECTED
MAGNETIC
HEADING
E
FIG. A
FIG. B
MILES
HEADING SET
COURSE SET
COURSE
045
090
N
3
6
E
12
15
S
21
24
W
30
33

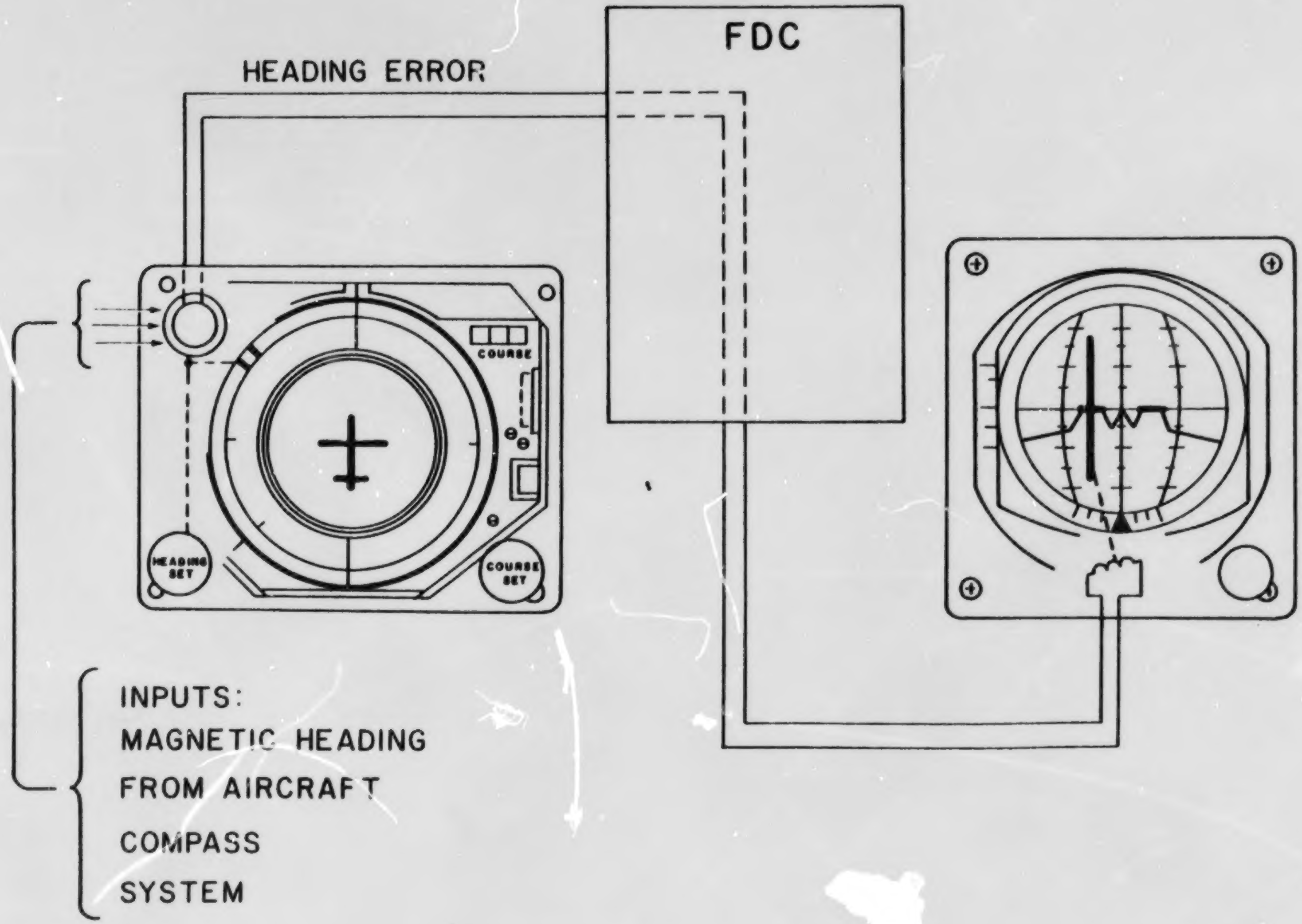
2059

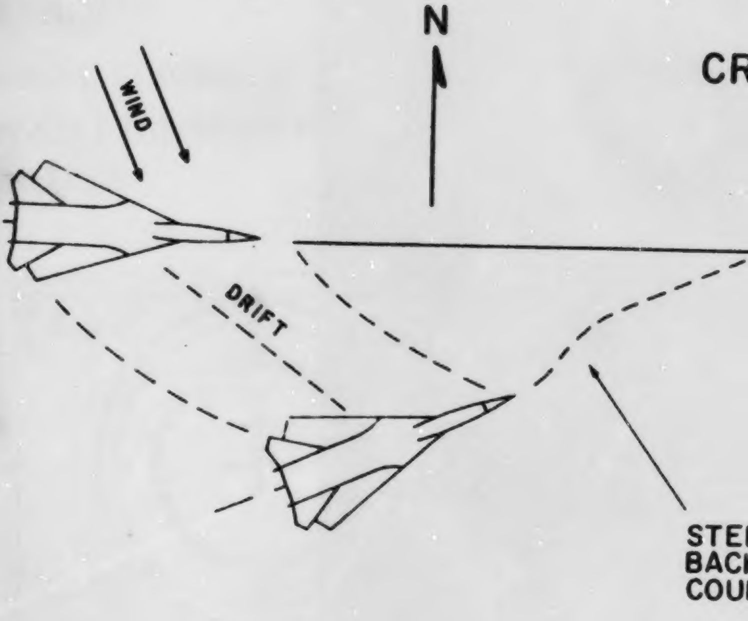
MAN HDG

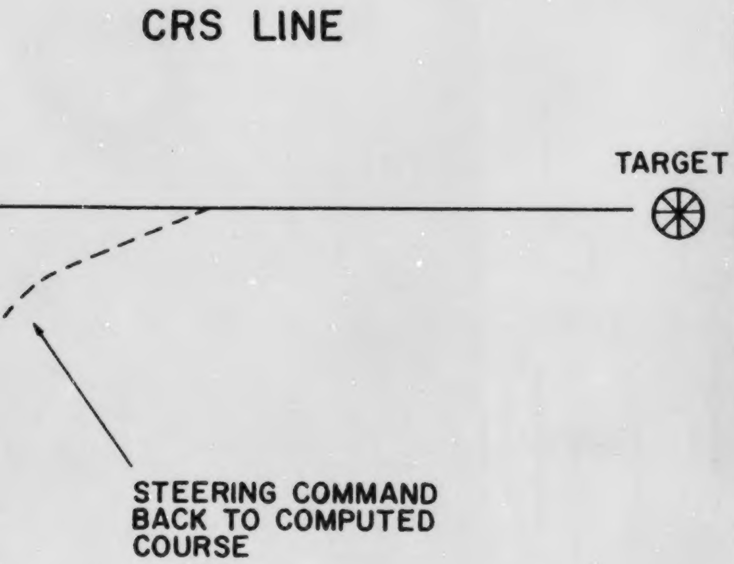

N
DESIRED HEADING
MILES
HEADING SET
N
3
6
E
12
15
S
21
24
W
30
33
010
COURSE
COURSE SET

2158

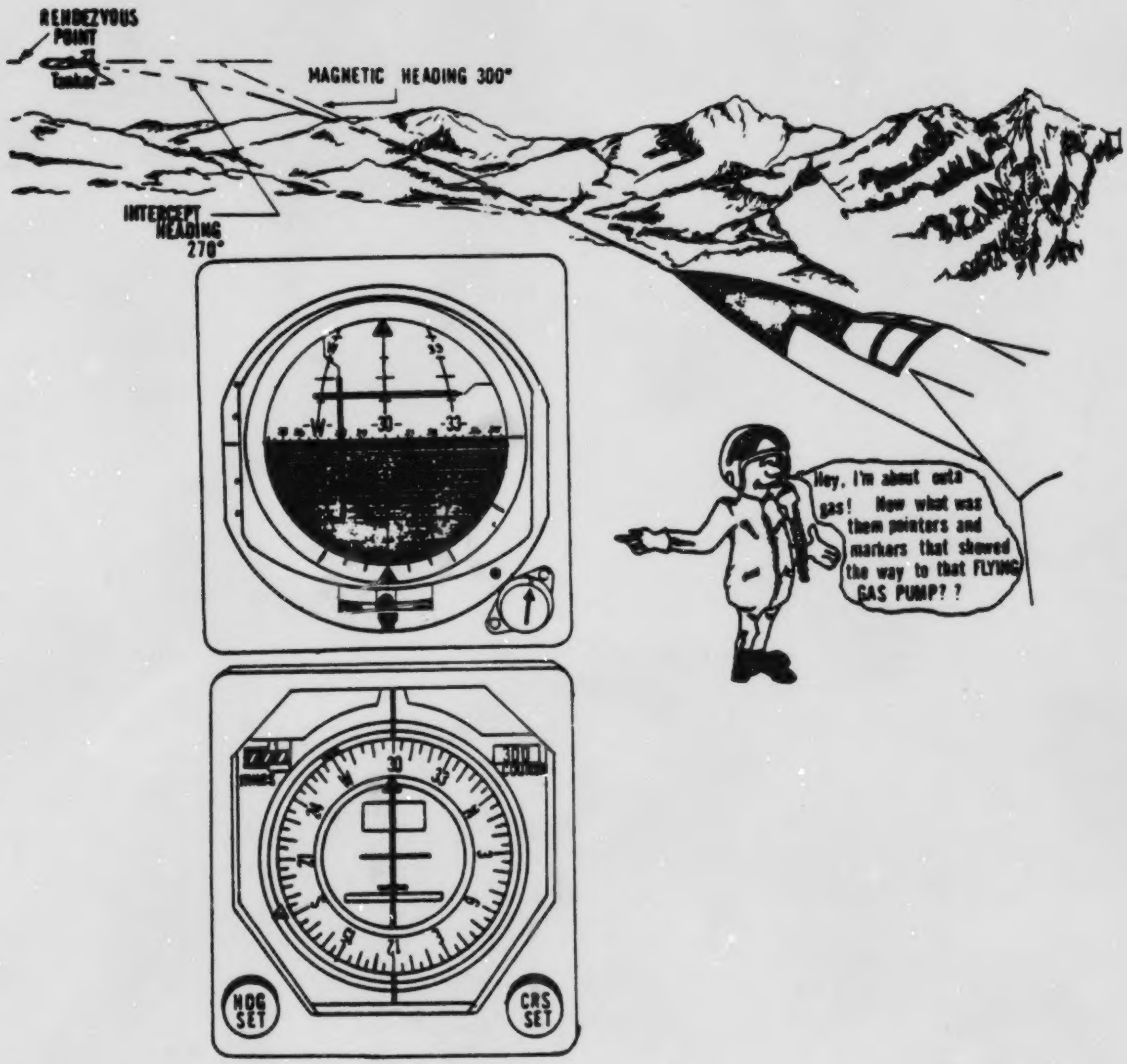
2157


HEADING ERROR
FDC
COURSE
HEADING SET
COURSE SET
INPUTS:
MAGNETIC HEADING
FROM AIRCRAFT
COMPASS
SYSTEM


N
CR
WIND
DRIFT
STE
BACK
COU


CRS LINE
TARGET
STEERING COMMAND BACK TO COMPUTED COURSE

2161


RENDEZVOUS POINT
Tanker
MAGNETIC HEADING 300°
INTERCEPT HEADING 270°
Hey, I'm about outa gas! Now what was them pointers and markers that showed the way to that FLYING GAS PUMP? ?
HDG SET
CRS SET

2063

HANDOUT
3ABR32531-HO-404A
3ABR32632B-HO-504A

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionic Systems Specialist

FLIGHT DIRECTOR SYSTEMS DIAGRAMS

5 July 1977

3350 TECHNICAL TRAINING WING
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2163

2064

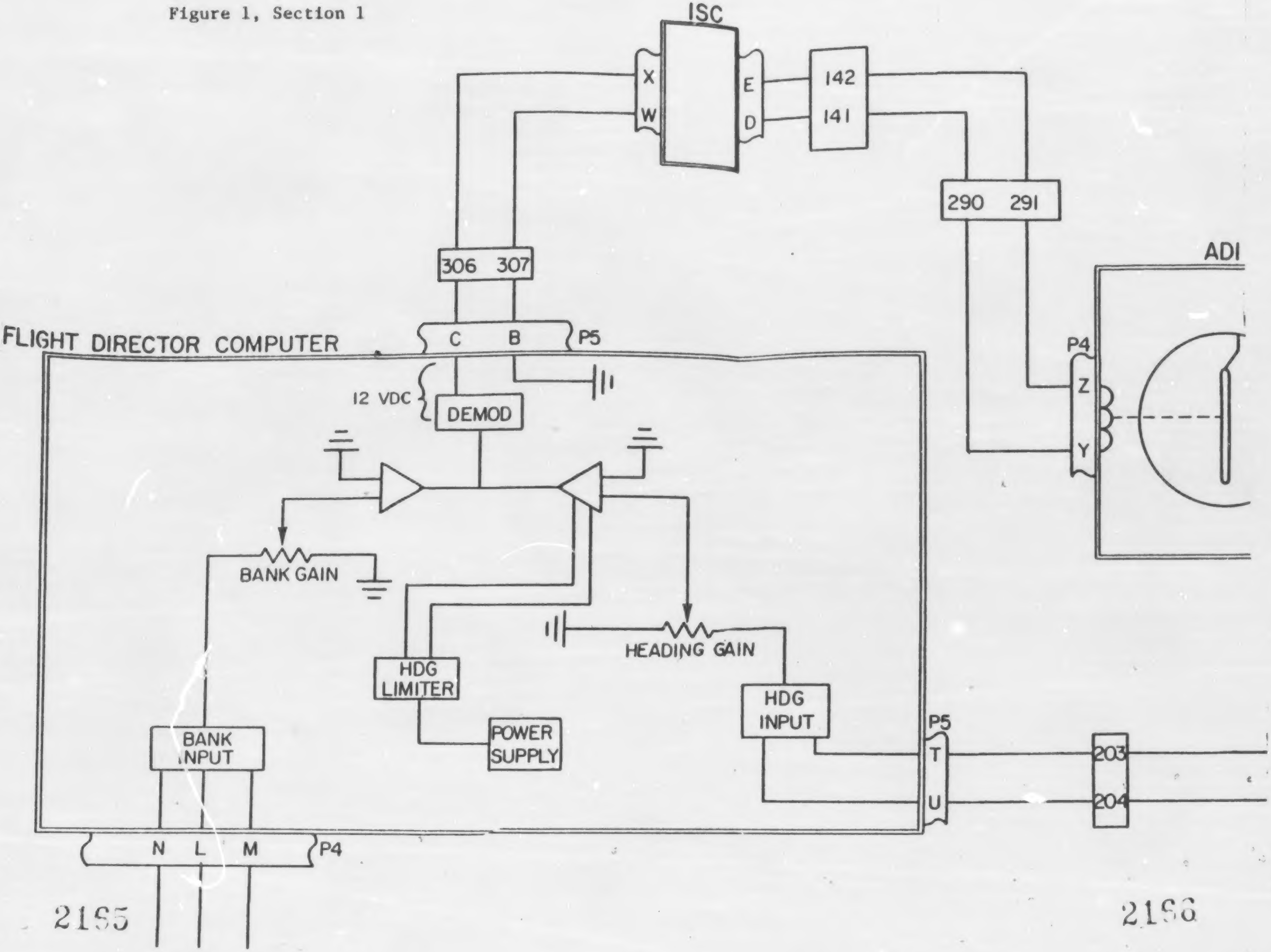
FOREWORD

This handout was designed for use in the 3ABR32531, Avionics Instrument Systems Specialist course, and the 3ABR32632B, Integrated Avionic Systems Specialist course. The schematic diagrams in this handout support the programmed texts and workbooks for the Flight Director System. The diagrams will be used by the students as directed by the instructor.

Supersedes 3ABR32531-HO-406A, 3ABR32632B-HO-407A, 3 February 1976.
OPR: 3360 TTG
DISTRIBUTION: X
3360 TTGTC-W - 200; TTVSR - 1

2184

Figure 1, Section 1


ISC
X
W
E
D
142
141
290
291
306
307
ADI
P5
C
B
FLIGHT DIRECTOR COMPUTER
P4
Z
Y
12 VDC
DEMOD
BANK GAIN
HEADING GAIN
HDG LIMITER
POWER SUPPLY
HDG INPUT
BANK INPUT
P5
T
U
203
204
N
L
M
P4

2065

MANUAL HEADING MODE

Figure 1, Section 2

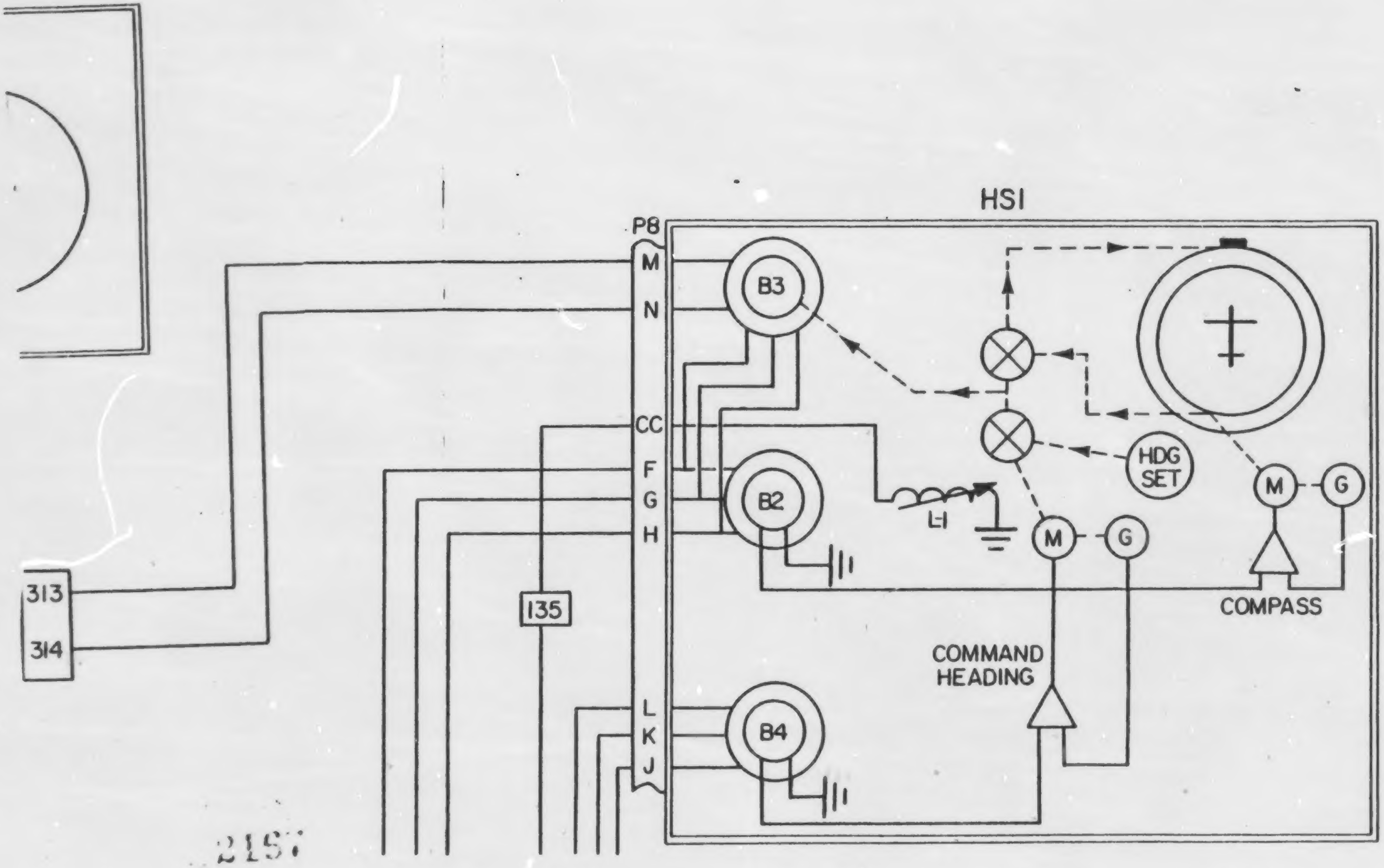
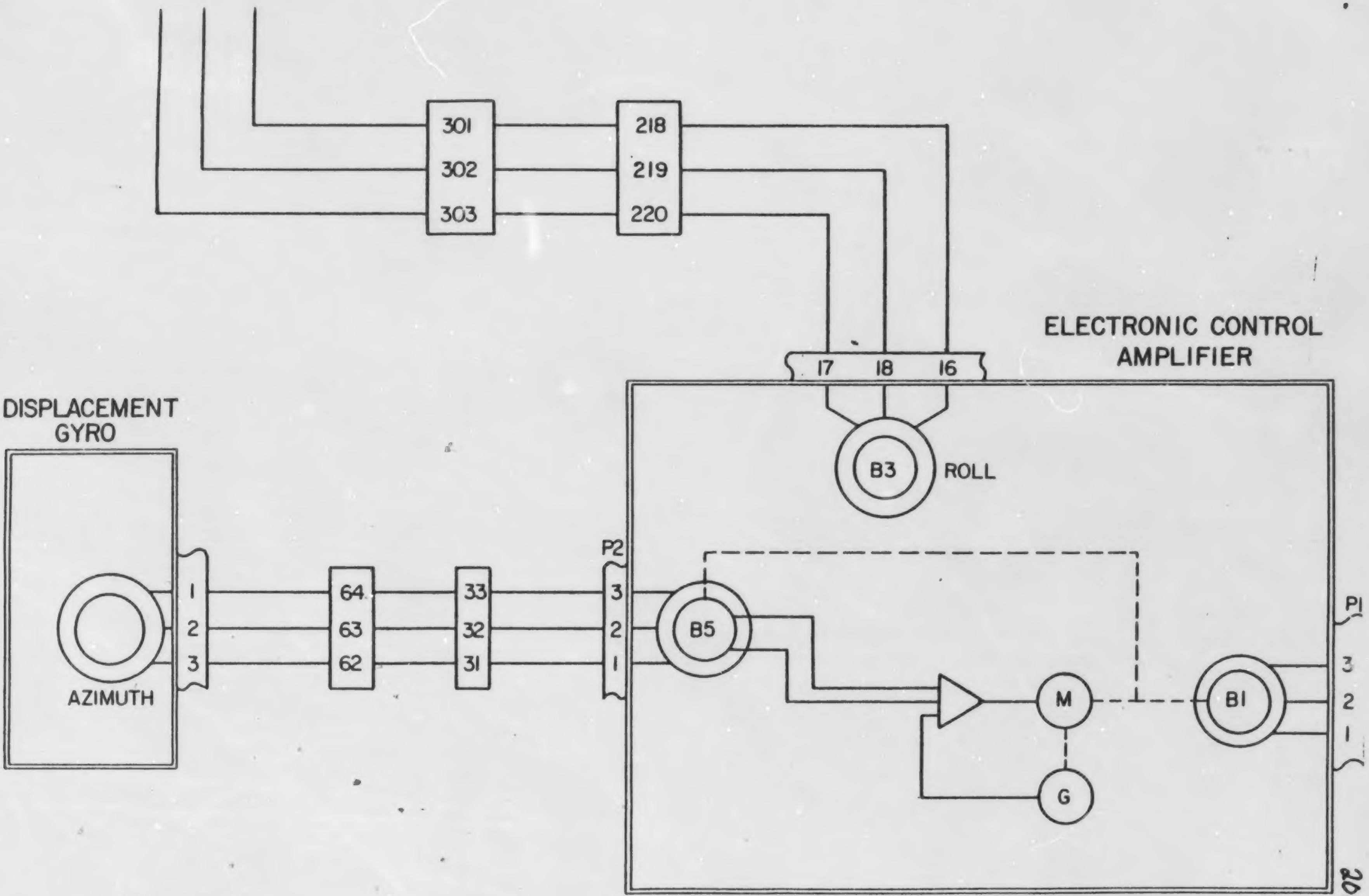

HSI
P8
M
N
CC
F
G
H
L
K
J
B3
B2
B4
L-1
HDG SET
M
G
M
G
COMPASS
COMMAND HEADING
313
314
135

Figure 1, Section 3


301
302
303
218
219
220
17
18
16
ELECTRONIC CONTROL AMPLIFIER
B3
ROLL
DISPLACEMENT GYRO
AZIMUTH
1
2
3
64
63
62
33
32
31
P2
3
2
1
B5
M
G
B1
P1
3
2
1

2067

2169

2170

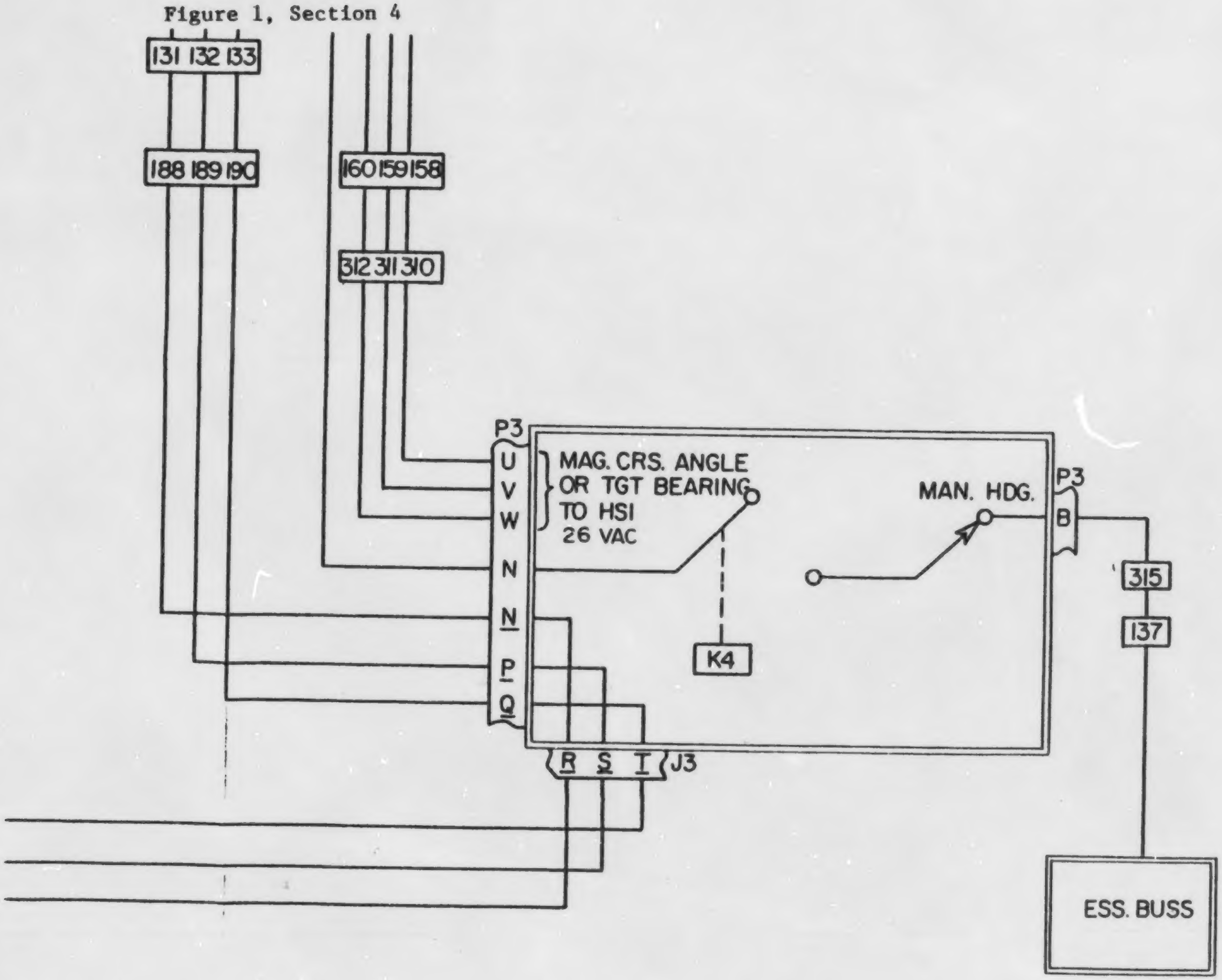


Figure 1, Section 4
131 132 133
188 189 190
160 159 158
312 311 310
P3
U
V
W
MAG. CRS. ANGLE
OR TGT BEARING
TO HSI
26 VAC
N
N
P
Q
K4
MAN. HDG.
P3
B
315
137
R S T
J3
ESS. BUSS

TACAN MODE

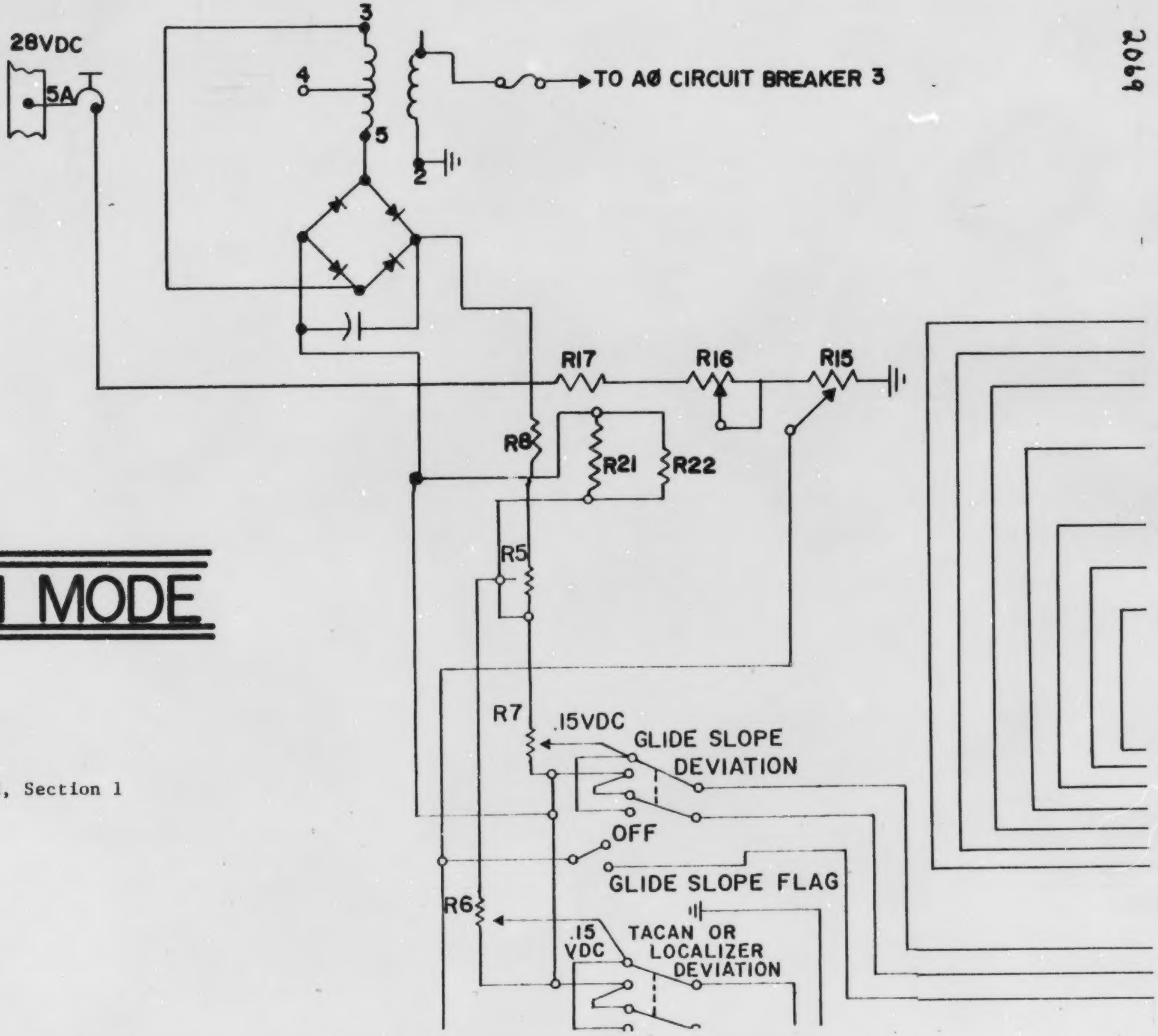
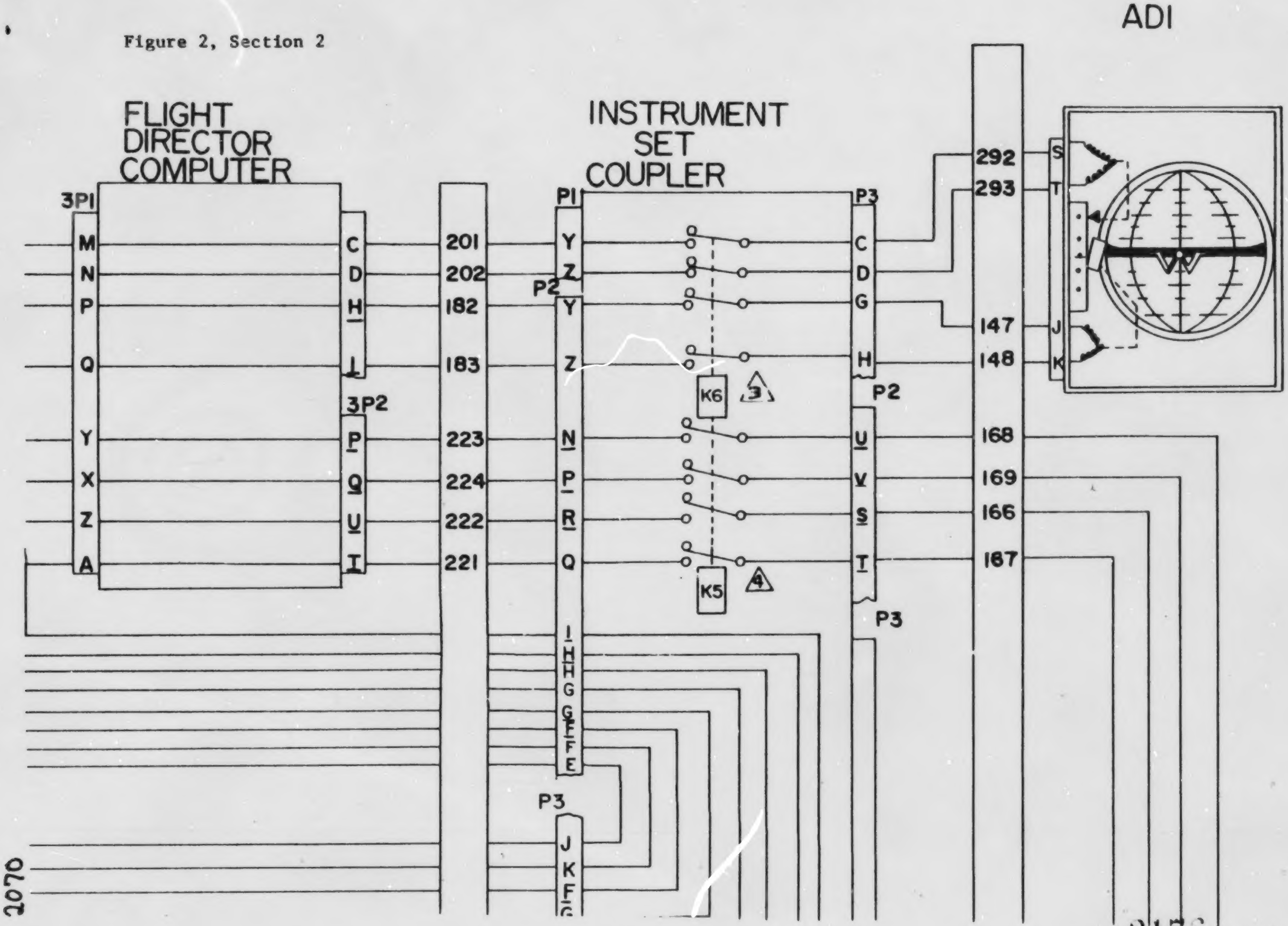

28VDC
5A
3
4
5
2
TO AØ CIRCUIT BREAKER 3
R17
R16
R15
R8
R21
R22
R5
R7
.15VDC
GLIDE SLOPE
DEVIATION
OFF
GLIDE SLOPE FLAG
R6
.15
VDC
TACAN OR
LOCALIZER
DEVIATION

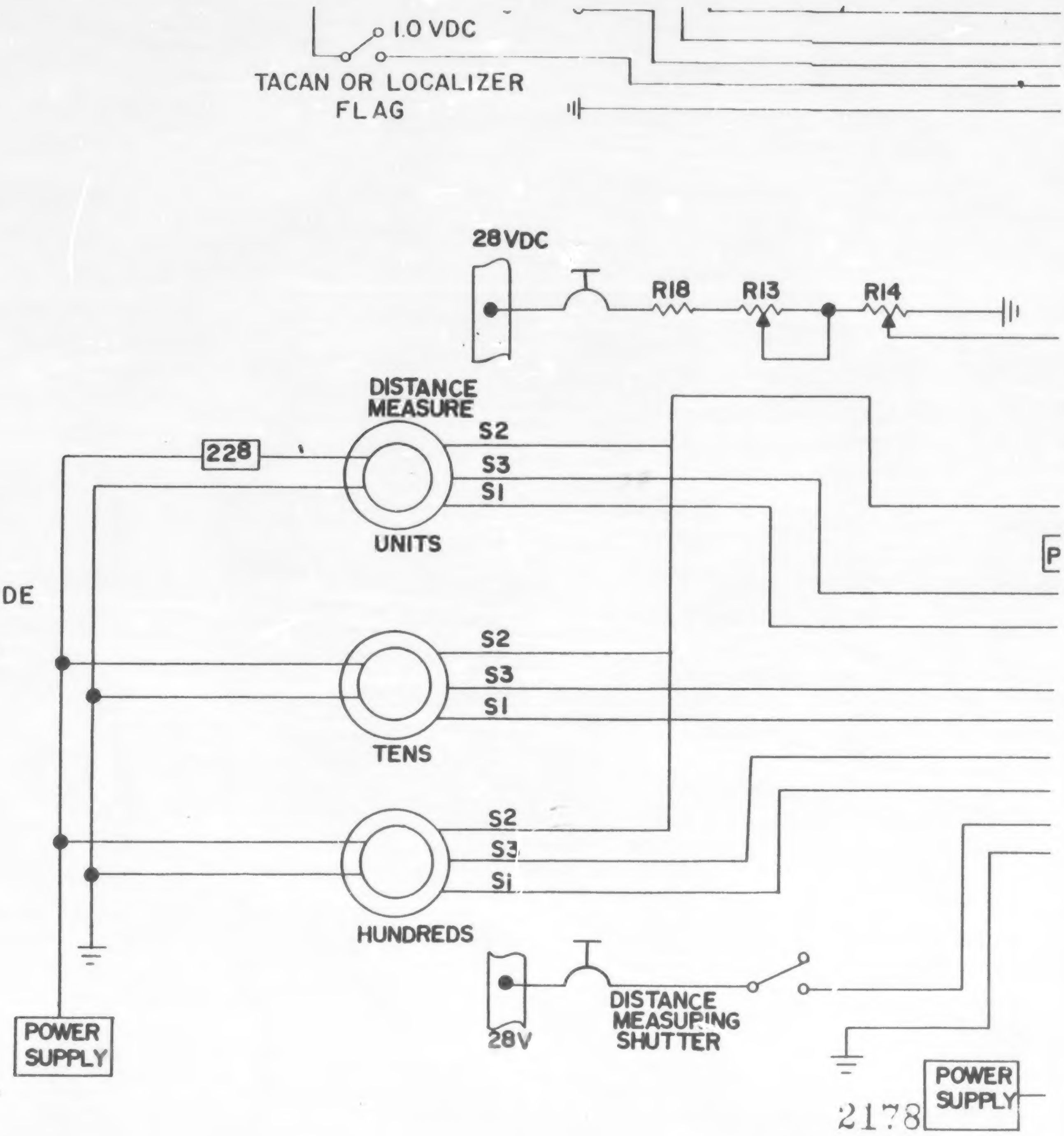
Figure 2, Section 1

Figure 2, Section 2


FLIGHT DIRECTOR COMPUTER
3PI
M
N
P
Q
Y
X
Z
A
C
D
H
J
3P2
P
Q
U
I
201
202
182
183
223
224
222
221
INSTRUMENT SET COUPLER
PI
Y
Z
P2
Y
Z
N
P
R
Q
I
H
H
G
G
F
F
E
P3
J
K
F
G
K6
3
K5
4
P3
C
D
G
H
P2
U
V
S
T
P3
292
293
147
148
168
169
166
167
ADI
S
T
J
K

2071

Figure 2, Section 3


1.0 VDC
TACAN OR LOCALIZER FLAG
28VDC
R18
R13
R14
DISTANCE MEASURE
228
S2
S3
S1
UNITS
P
S2
S3
S1
TENS
S2
S3
S1
HUNDREDS
POWER SUPPLY
28V
DISTANCE MEASURING SHUTTER
POWER SUPPLY

LEGEND

- △3 K6 ENERGIZED IN ILS MODE
- △4 K5 ENERGIZED IN ILS OR TACAN MODE

2177

2178

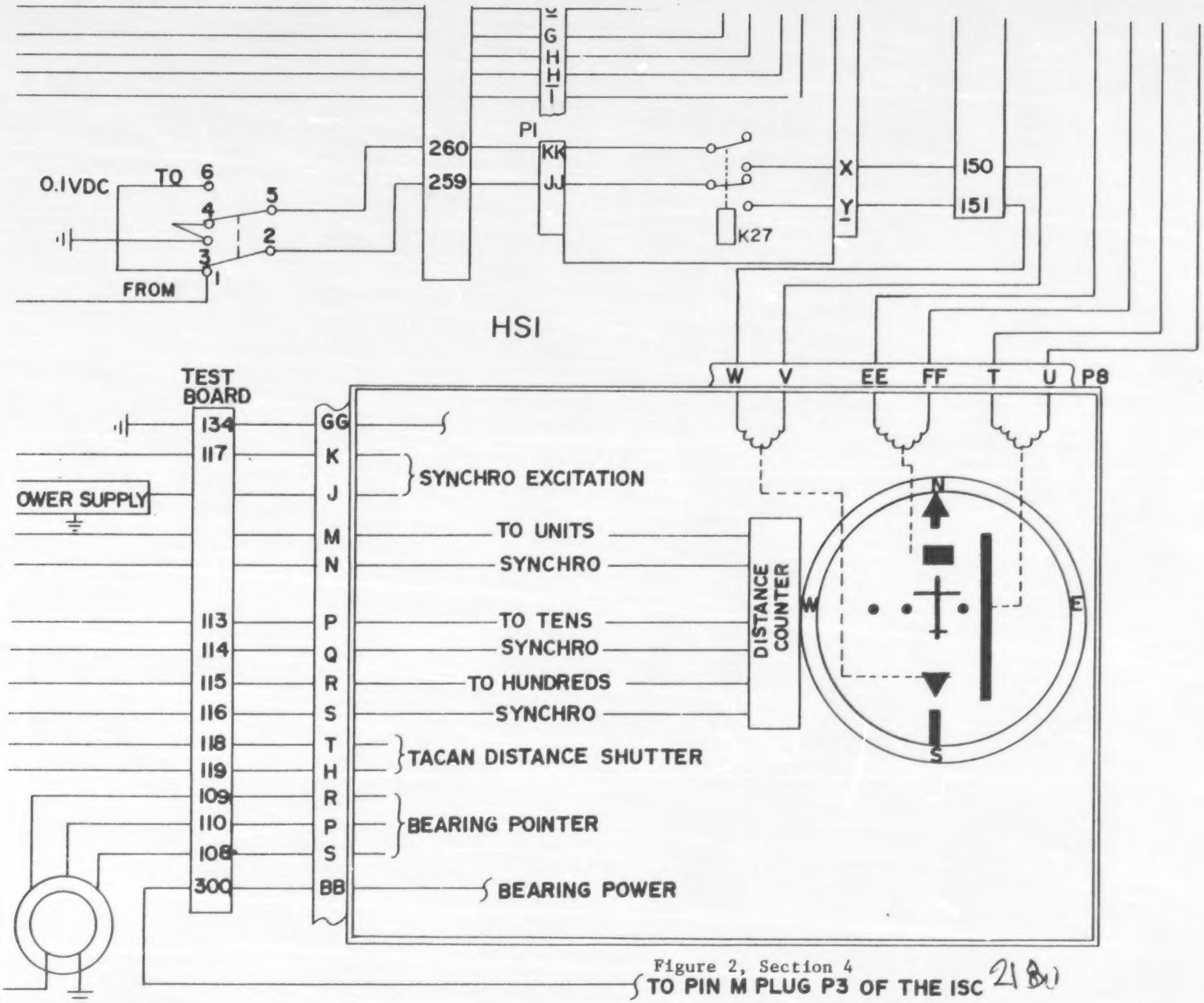

G
H
H
I
PI
260
259
KK
JJ
0.1VDC
TO 6
5
4
3
2
1
FROM
K27
X
Y
150
151
HSI
TEST BOARD
W
V
EE
FF
T
U
P8
134
117
113
114
115
116
118
119
109
110
108
300
GG
K
J
M
N
P
Q
R
S
T
H
R
P
S
BB
SYNCHRO EXCITATION
OWER SUPPLY
TO UNITS
SYNCHRO
TO TENS
SYNCHRO
TO HUNDREDS
SYNCHRO
DISTANCE COUNTER
N
W
E
S
TACAN DISTANCE SHUTTER
BEARING POINTER
BEARING POWER
TO PIN M PLUG P3 OF THE ISC

Figure 2, Section 4

2073

Figure 3, Section 1

OFF MODE WITH ALTITUDE REFERENCE

SUB MODE

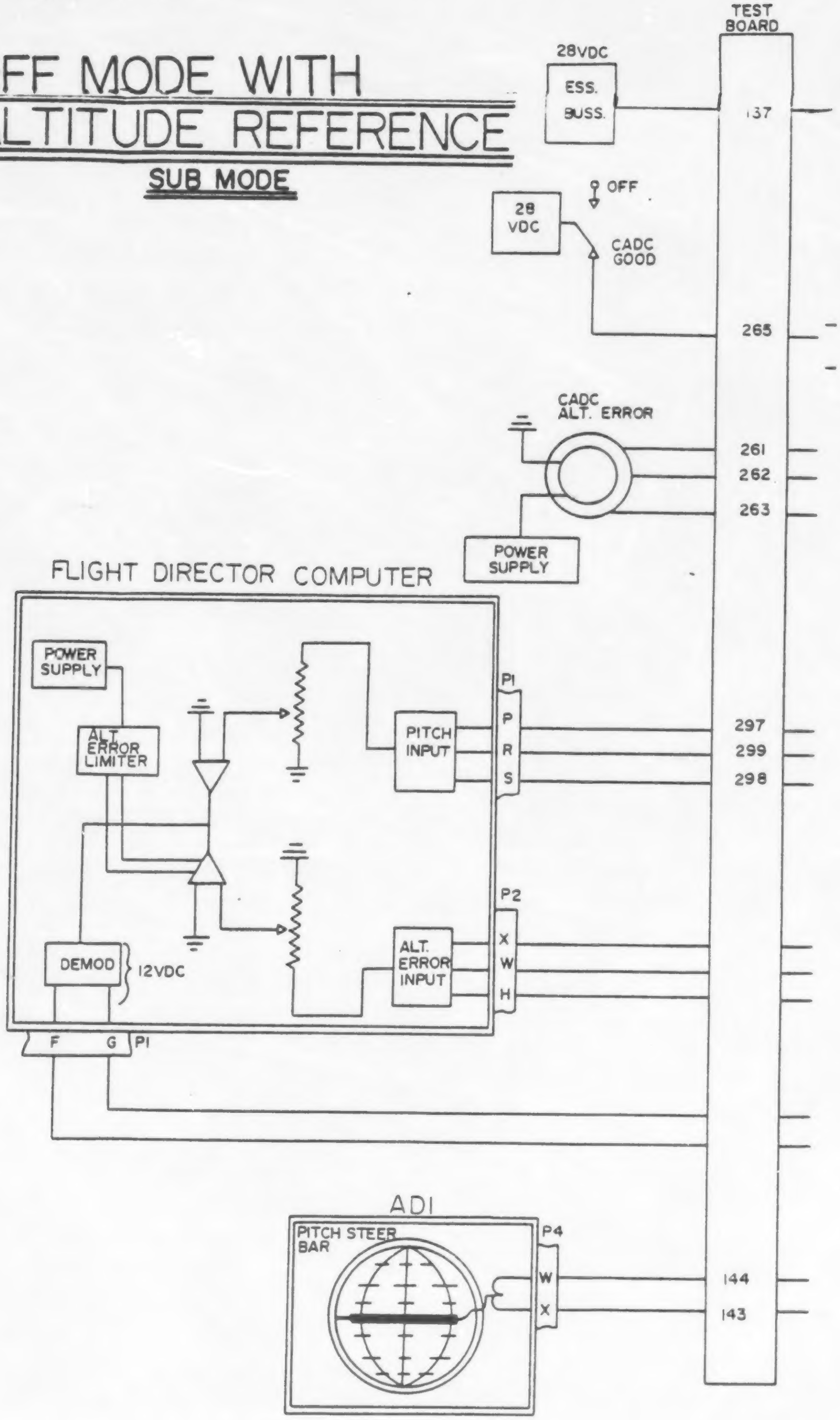
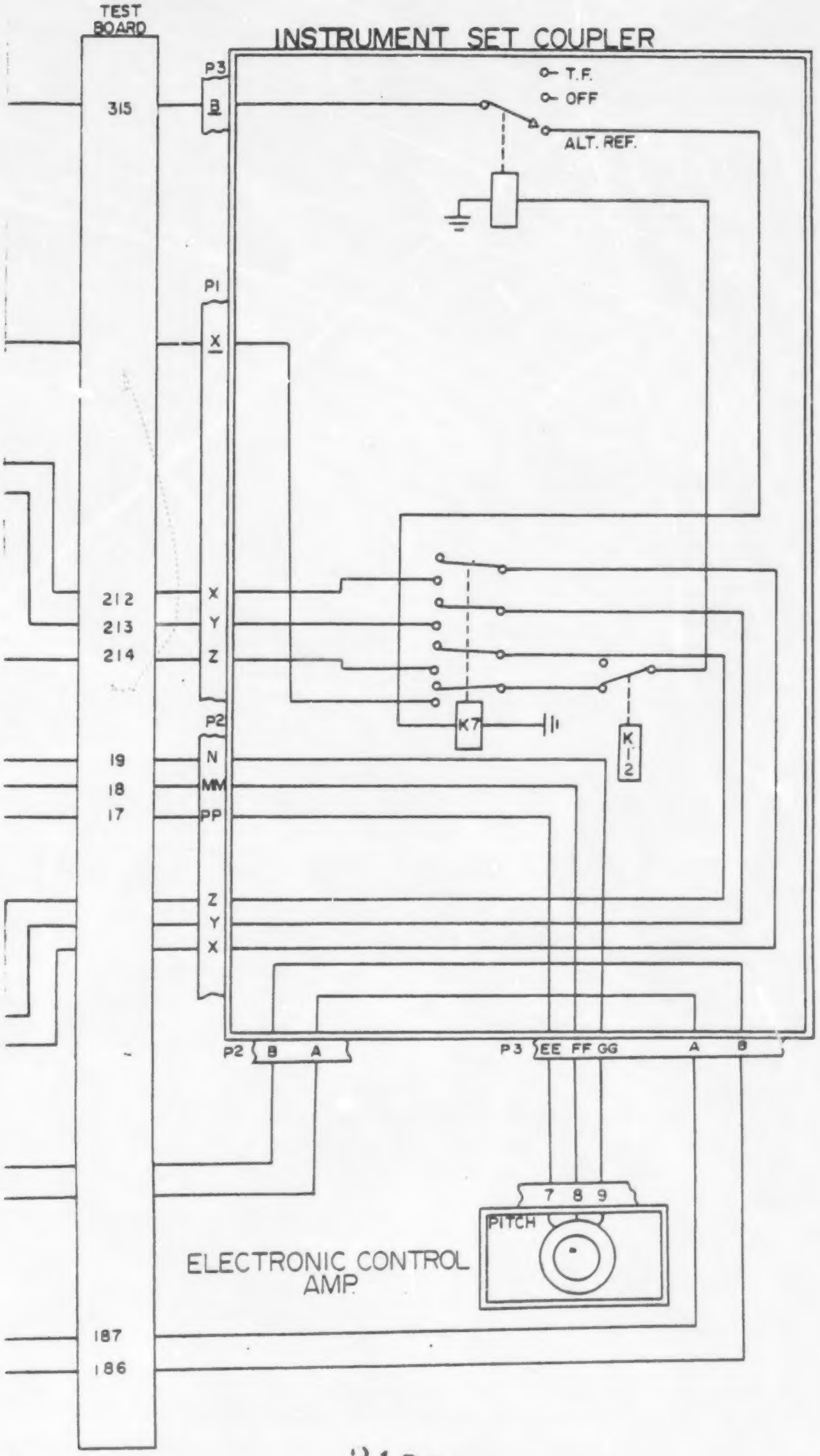

TEST BOARD
28VDC
ESS. BUSS.
137
28 VDC
OFF
CADC GOOD
265
CADC ALT. ERROR
261
262
263
POWER SUPPLY
FLIGHT DIRECTOR COMPUTER
POWER SUPPLY
ALT. ERROR LIMITER
PITCH INPUT
P1
P
R
S
297
299
298
P2
X
W
H
DEMOD
12VDC
ALT. ERROR INPUT
F
G
P1
ADI
PITCH STEER BAR
P4
W
X
144
143

Figure 3, Section 2


TEST BOARD
INSTRUMENT SET COUPLER
P3
B
T.F.
OFF
ALT. REF.
P1
X
315
212
213
214
X
Y
Z
K7
K1 2
P2
N
MM
PP
19
18
17
Z
Y
X
P2
B
A
P3
EE
FF
GG
A
B
7
8
9
PITCH
ELECTRONIC CONTROL AMP.
187
186

2075

WORKBOOK

3ABR32531-WB-501 (404)
3ABR32632B-WB-506 (504)

Technical Training

Avionics Instrument Systems Specialist
Integrated Avionics Systems Specialist

FLIGHT DIRECTOR SYSTEMS

7 March 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2183

2076

Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32531-WB-404
3ABR32632B-WB-504

FLIGHT DIRECTOR SYSTEM

OBJECTIVES

Given a workbook and trainer, perform an inspection and operational check of the Flight Director System with a minimum of 100% accurate workbook responses.

Given a workbook, test equipment and trainer, troubleshoot the Flight Director System with a minimum of 80% accurate workbook responses.

Given a workbook, test equipment and trainer, bench check components of the Flight Director System with a minimum of 80% accurate workbook responses.

NOTE: Students enrolled in the 3ABR32632B, Integrated Avionic Systems Specialist Course will complete ONLY the first two (2) objectives as listed above. Students enrolled in the 3ABR32531, Avionics Instrument Systems Specialist Course, will complete all listed objectives.

INSTRUCTIONS

The laboratory instructor will supply you with the materials required to complete the appropriate sections of this workbook. Take your time DO NOT RUSH. If you have any difficulties with any part of this workbook ask your instructor for assistance. DO NOT attempt any step that you do not understand until you check with the instructor.

EQUIPMENT

	Basis of Issue
Auxiliary Flight Reference Trainer	1/student
Schematic Diagrams (Flight Director Sys)	1/student
Workbook 3ABR32531-WB-406	1/student
Multimeter AN/PSM-6	1/student
ASM-159 Test Set, Nav. Subsystem	1/student
HSI	1/student

PROCEDURE

Due to the limited number of trainers, you may have to work with an assistant during operational procedures. After completing the procedures once, you and your assistant will change positions so that each will operate the controls and each will observe the indications and note the malfunctions. Record your results in the spaces provided, and indicate if the checks were satisfactory or unsatisfactory. This workbook will be checked by your instructor. REMOVE ALL JEWELRY!

1. INSPECTION:

   a. Inspect the trainer for damage or missing components, disconnected or damaged plugs or wiring. List any discrepancy found during the inspection below.

Supersedes 3ABR32531-WB-404, 3ABR32632B-WB-504, 20 June 1977.
OPR: 3360 TCHTG
DISTRIBUTION: X
3360 TCHTG/TTGU-F - 250; TTVSA - 1

2184

Note: The silhouette stand is an outline of the aircraft and contains the Rate Gyroscope Transmitter, Displacement Gyroscope, and Remote Compass Transmitter.

b. To ensure smooth operation of the silhouette, loosen the hoding knobs beneath the silhouette stand, and move the silhouette through pitch, roll, and azimuth. Using the bubble level provided on the silhouette, level the silhouette and tighten the holding knobs.

Note: Inform your instructor of any binding that occurs when the silhouette is used. CAUTION: DO NOT rotate the silhouette more than 360 degrees CW or CCW because damage may result to the electrical wiring.

2. INITIAL SWITCH SETTINGS:

a. Insure that the trainer power switches are in the OFF position.

Note: All synchro settings will be made using the OUTER RING. DO NOT use the center knob. Using the center knob causes misalignment and places error into the system.

b. Initial setting of simulator control panel on rear of trainer.

CONTROL	POSITION	PURPOSE AND USE
Pull Up Switch	OFF	Applies 28V DC pull up signal to ISC for weapon control simulation.
Pri. Att. Good	OFF	Provides for NCU input for reference system operation. Switch in OFF position simulates a primary navigational system malfunction.
Flag Control	OFF	Controls power to the vertical steering pointer and course deviation bar off flags.
AFRS Switch	NORMAL	Simulates malfunction of AUX ATT caution lamp.
Simulated Beam Sensor Trip Switch	OFF	Simulates beam sensor trip signal from converter set.
CADC Good Switch	GOOD	Switch in ON position provides signal of central air data computer good.
TF Transmitter Good Switch	GOOD	Simulates TF XMTR signal from TF receiver.
Pitch or Climb/Dive Steering Control	FULL COUNTER CLOCKWISE	-Simulates pitch attitudes and direction from weapons system and terrain following radar.

CONTROL	POSITION	PURPOSE AND USE
Pitch or Climb/Dive Steering Switch	UP	Same as above.
Horizontal Steering Control Knob	FULL COUNTER-CLOCKWISE	Simulates azimuth steering outputs from navigation computer unit. Controls magnitude and direction of output to ISC.
Horizontal Steering Switch	RIGHT	Same as above.
Course Deviation Bar Control	FULL COUNTER-CLOCKWISE	Simulates course deviation signal from converter set to ISC.
Course Deviation Bar Switch	RIGHT	Same as above.
Target Bearing Synchro	ZERO (adjust outer ring only)	Simulates target bearing inputs to HSI from attack radar system.
Magnetic Course Angle Synchro	ZERO (adjust outer ring only)	Simulates magnetic course angle from converter set.
True Ground Track Synchro	ZERO (adjust outer ring only)	Simulates inputs in conjunction with magnetic variation to provide ground course to HSI.
Magnetic Variation Synchro	ZERO (adjust outer ring only)	Simulates magnetic variation inputs to HSI.
CADC Altitude Error Synchro	ZERO (adjust outer ring only)	Simulates altitude error signals from central air data computer.
Pitch and Tilt Synchro	ZERO (adjust outer ring only)	Simulates pitch and tilt input signals to ISC from attack radar system.
Tacan Distance Measuring Hundreds Synchro	ZERO (adjust outer ring only)	Simulates distance to or from the selected TACAN station input signals to both the HSI and BDHI.
Tacan Tens Synchro	ZERO (adjust outer ring only)	Same as above.
Tacan Units Synchro	ZERO (adjust outer ring only)	Same as above.

CONTROL	POSITION	PURPOSE AND USE
Valid Switch	OFF	Simulates valid input to the HSI and BDHI.
Tacan Bearing Synchro	ZERO (adjust outer ring only	Simulates bearing to or from the selected TACAN station inputs to HSI and BDHI.
To-From Switch	TO	Simulates bearing to or from the selected TACAN station inputs to HSI and BDHI.
Tacan or Localizer Deviation Control	FULL COUNTER-CLOCKWISE	Simulates deviation (left or right) inputs and flag position to ADI.
Left-Right Switch	RIGHT	Same as above.
Flag Switch	OFF	Same as above.
Glide Slope Deviation Control	FULL CLOCKWISE	Simulates deviation from glide slope.
Up-Down Switch	UP	Same as above.
Flag Switch	OFF	Same as above.
Trouble Switches	OUT	Simulates trouble in the system.

c. Initial setting of pilot's instrument panel controls.

CONTROL	LOCATION	POSITION
Mode Selector	Instrument Set Coupler	OFF (push to turn)
Pitch Steer Switch	Instrument Set Coupler	OFF
Flt. Inst. Ref.	Misc. Switch Panel	AUX
Course Set	HSI	000
Gyros Switch	Ground Check Panel	OFF
Mode Selector	Compass System Controller	Slaved
Latitude Select	Compass System Controller	40 degrees
Hemisphere Switch	Compass System Controller	N

CONTROL	LOCATION	POSITION
Pitch Trim Knob	ADI	Center (arrow to white dot)
Pitch Trim Knob	SAI	Center (arrow to white dot)
Radar Alt. Switch	Above Misc. Switch Panel	OFF

Note: Report any unsatisfactory results to your instructor immediately.

3. INITIAL OPERATIONAL CHECK PROCEDURES:

a. Ensure all switches and synchros are in the prescribed positions. (Completion of Initial Switch Setting list)

b. Power:

(1) Connect 115V AC, 400Hz, 3Ø and 28V DC power cables to the outlets suspended from the ceiling.

(2) Turn power switches ON and observe that the AC and DC power lamps are illuminated.

Results of Check			
S		U	

Note: Steps 3 and 4 are timed items.

(3) To apply power to the Auxiliary Flight Reference System, position the GYROS-OFF switch to GYROS. Observe that the AUX-ATT lamp on the caution light panel is lighted and the ADI and SAI off flags are in view. The OFF flag on the BDHI shall go out of view within 15 seconds after the GYROS-OFF switch is positioned to GYROS.

Results of Check			
S		U	

(4) Wait two minutes for the system to stabilize. Observe that within two minutes the AUX ATT lamp, on the caution panel, goes out and the ADI and SAI off flags go out of view.

Results of Check			
S		U	

c. Fast erection.

(1) Depress and hold the FAST ERECT switch, on the miscellaneous display panel.

(2) Observe the ADI, SAI, and AUX ATT lamp, on the caution panel. The off flags shall come into view and the AUX ATT lamp shall light.

Results of Check			
S		U	

(3) Release the FAST ERECT switch.

(4) The off flags on the ADI and SAI shall disappear and the AUX ATT lamp shall go out.

Results of Check			
S		U	

4. FLIGHT DIRECTOR SELF TEST CHECKS:

a. ALT REF self test:

(1) Move the Mode Selector, on the ISC, Alt Ref, and INSTR TEST switches to the positions given in Figure 1.

(2) Indicate if the checks are satisfactory or unsatisfactory.

(3) When you have completed all the checks given in Figure 1, return all switches to their original positions given in Step 2b.

ISC SWITCH POSITION		INSTR TEST SWITCH	ADI DISPLAY PITCH STEERING BAR	RESULTS	
MODE SEL	PITCH STEER ALT REF			S	U
OFF	Engaged	Not engaged	In view and centered		
OFF	Engaged	Engaged	Deflects approx 1 inch upward		
ILS	Engaged	Not engaged	In view and centered		
AILS	Engaged	Not engaged	In view and centered		
TACAN	Engaged	Not engaged	In view and centered		
CRS SEL NAV	Engaged	Not engaged	In view and centered		
BOMB/NAV	Engaged	Engaged	Deflects approx 1 inch upward		
CRS LINE	Engaged	Not engaged	In view and centered		
MAN CRS	Engaged	Not engaged	In view and centered		
MAN HDG	Engaged	Engaged	Deflects approx 1 inch upward		
TKR RV	Drops to OFF	Not engaged	In view and centered		

Figure 1. Alt Ref Self Test.

2082

b. OFF mode self test:

(1) For this test the ISC mode selector will remain in the OFF position.

Note: After the next two steps are completed, these conditions will remain the same for the rest of the self tests and operational checks.

(2, Place the Compass System Controller to DG.

(3) Depress and rotate the HDG Set knob on the Compass System Controller until the heading marker is under the upper lubber line.

(4) Observe the indications given in Figure 2 on the ADI and HSI.

Note: Check the ADI and HSI before and during each test. During test means, depressing the INSTR test switch on the Ground Check Panel and observing the pointer deflection, if any, on the ADI and HSI.

HSI					ADI				
DISPLAY	BEFORE TEST	DURING TEST	S	U	DISPLAY	BEFORE TEST	DURING TEST	S	U
Course Dev Bar	Centered	Centered			Bank Steer Bar	Out of view	Out of view		
Dev Bar	Out of view	Out of view			Course Warning Flag	Out of view	Out of view		
					Glide Slope Pointer	Out of view	Out of view		
					Glide Slope Warning Flag	Out of view	Out of view		
					Pitch Steer Bar	Out of view	Out of view		

Figure 2. OFF Mode Self Test.

2190

c. ILS self test.

(1) Place ISC mode selector to ILS.

(2) Turn the glide slope deviation control knob, on the simulator panel, full counterclockwise.

(3) Check the HSI and ADI displays, as given in Figure 3, before and during the test.

Note: After you have completed the checks given in Figure 3, return the glide slope deviation control knob to the full clockwise position.

HSI					ADI				
DISPLAY	BEFORE TEST	DURING TEST	S	U	DISPLAY	BEFORE TEST	DURING TEST	S	U
Course Dev Bar	Centered	Two dots right			Bank Steer Bar	Centered	Deflects ½ inch right		
Dev Bar Alarm Flag	In view	Out of view			Course Warning Flag	In view	Out of view		
					Glide Slope Pointer	Centered	Two dots down		
					Glide Slope Warning Flag	In view	Out of view		
					Pitch Steer Bar	Out of view	Out of view		

Figure 3. ILS Self Test.

2084

d. TACAN self test.

(1) Place the ISC mode selector to TACAN.

(2) Check the HSI and ADI displays, as given in Figure 4, before and during test.

HSI					ADI				
DISPLAY	BEFORE TEST	DURING TEST	S	U	DISPLAY	BEFORE TEST	DURING TEST	S	U
Course Dev Bar	Centered	Two dots right			Bank Steer Bar	Centered	Deflects about 1/2 right		
Dev Bar Alarm Flag	In view	Out of view			Course Warning Flag	In view	Out of view		
					Glide Slope Pointer	Out of view	Out of view		
					Glide Slope Warning Flag	Out of view	Out of view		
					Pitch Steer Bar	Out of view	Out of view		

Figure 4. TACAN Self Test.

2192

e. MAN HDG self test.

(1) Place the ISC mode selector to MAN HDG.

(2) Check the HSI and ADI displays, as given in Figure 5, before and during test.

(3) After completion of this test return the ISC mode selector to the OFF position.

HSI					ADI				
DISPLAY	BEFORE TEST	DURING TEST	S	U	DISPLAY	BEFORE TEST	DURING TEST	S	U
Course Dev Bar	Centered	Centered			Bank Steer Bar	Centered	Centered		
Dev Bar Alarm Flag	Out of view	Out of view			Course Warning Flag	Out of view	Out of view		
					Glide Slope Pointer	Out of view	Out of view		
					Glide Slope Warning Flag	Out of view	Out of view		
					Pitch Steer Bar	Out of view	Out of view		

Figure 5. MAN HDG Self Test.

5. SYSTEM OPERATIONAL CHECKS.

a. OFF mode check out:

(1) Ensure that all switches and controls are in the positions given in Step 2b, and that the heading marker and bearing pointer are under the upper lubber line.

(2) With the ISC in the OFF position, observe the ADI and HSI. On the ADI all pointers and warning flags will be out of view. On the HSI the course deviation warning flag will be out of view and the course deviation bar will be centered.

Result of Check			
S		U	

(3) Move the Pitch Steer switch to the ALT REF position. Result: The horizontal steering pointer on the ADI will come into view and be centered.

Result of Check			
S		U	

(4) Rotate the CADC Alt Error synchro clockwise. Result: The horizontal steering pointer will indicate a dive command.

Result of Check			
S		U	

b. ILS mode check out:

(1) Ensure that all switches and controls are in the positions given in Step 2b, and that the heading marker and bearing pointer are under the upper lubber line.

(2) Place the ISC mode selector to ILS and pitch steer switch to ALT Ref position. Move the silhouette in roll, pitch, and azimuth. Result: The ADI, HSI, SAI, and BDHI indications shall correspond to the silhouette movement.

Result of Check			
S		U	

(3) Place the silhouette in a climb right wing low attitude. Result: The horizontal steering pointer will indicate a dive command and then slowly decay to center.

Result of Check			
S		U	

(4) On the Simulator Control Panel, rotate the CADC Alt. Error synchro clockwise. Result: The horizontal steering pointer will indicate a dive command.

Results of Check			
S		U	

(5) Return the synchro dial to ZERO.

(6) Place the Tacan/Localizer and Glide Slope Flag switch to FLAG. Result: The course deviation warning flag on the HSI and the glide slope deviation warning flag on the ADI will go out of view.

Results of Check			
S		U	

(7) Slowly rotate the Glide Slope Deviation control knob counterclockwise. Result: The glide slope pointer will move towards center, when the pointer is almost centered the pitch steer switch shall disengage itself.

Results of Check			
S		U	

(8) Adjust the glide slope deviation control knob to keep the glide slope pointer centered.

(9) Vary the Tacan/Localizer Deviation Control knob. Result: The course deviation bar movement shall correspond to the movement of the control knob. If the deviation is two dots or greater the horizontal steering bar will drop out of view and will not reappear until the deviation bar is returned to center.

Results of Check			
S		U	

(10) Slowly vary the Glide Slope Deviation Control knob. Result: The horizontal steering pointer and the glide slope deviation pointer movement shall correspond to the movement of the control knob movement. When the glide slope deviation is two dots or greater the horizontal steering pointer shall go out of view and not return until the deviation has been reduced to zero.

Results of Check			
S		U	

(11) Vary the Magnetic Course Angle synchro dial clockwise and counterclockwise. Result: The heading marker on the HSI will follow the movement of the synchro dial.

Results of Check			
S		U	

(12) Vary the Tacan Bearing Synchros clockwise and counterclockwise. Result: The bearing pointer on the HSI and PDHI will follow the movement of the synchro dials.

Note: The bearing synchro closest to the TO-From switch controls the BDHI bearing pointer; the other synchro controls the HSI bearing pointer.

Results of Check			
S		U	

(13) Move the Tacan Distance Measuring Valid switch to VALID. Result: The range indicator warning flags on the HSI and BDHI shall go out of view.

Results of Check			
S		U	

(14) Move the Tacan Distance Measuring synchro dials as follows: Hundreds to 1, Tens to 5, and Units to 8. Result: The HSI and BDHI distance counters shall display 158 miles.

Results of Check			
S		U	

(15) Vary the HSI Course Set knob clockwise and counterclockwise. Result: The vertical steering pointer shall deflect right for clockwise movement and left for counterclockwise movement.

Results of Check			
S		U	

c. TACAN mode check out:

(1) Ensure that all switches and controls are in the positions given in Step 2b, and that the heading marker and bearing pointer are under the upper lubber line.

(2) Place the mode selector on the ISC to TACAN and the Pitch Steer switch to ALT REF.

(3) Place the Tacan/Localizer Flag switch to FLAG. Result: The ADI course warning and the HSI course deviation flag will go out of view.

Result of Check			
S		U	

(4) Rotate the Tacan/Localizer deviation control knob clockwise. Result: The vertical director pointer and the HSI course deviation bar will deflect to the right.

Results of Check			
S		U	

(5) Rotate the Magnetic Course Angle synchro in the clockwise direction. Result: The HSI heading marker movement shall correspond to the movement of the synchro dial.

Results of Check			
S		U	

(6) Rotate the Tacan Bearing synchro dials in a clockwise and counterclockwise direction. Results: The BDHI and HSI bearing pointers shall follow the movement of the dials.

Note: The BDHI will respond to the synchro dial closest to the To-From switch, and the HSI will follow the other synchro.

Results of Check			
S		U	

(7) Place the Tacan Distance Measuring Valid switch to VALID. Results: The range warning flags on the HSI and BDHI will go out of view.

Results of Check			
S		U	

(8) Rotate the Tacan Distance Measuring synchros to the following positions: Hundreds to 1, Tens to 2, Units to 7. Results: Both the HSI and BDHI range indicators will read 127.

Results of Check			
S		U	

(9) Rotate the CADC Altitude Error synchro dial clockwise. Results: The horizontal pointer shall indicate a dive command.

Results of Check			
S		U	

(10) Verify that the HSI To-From arrow indicates TO. Place the TO/From switch on the simulator panel to FROM. Results The To-From arrow shall indicate From.

Results of Check			
S		U	

(11) Verify the glide slope pointer is inactive (Out of view) and the glide slope warning flag is out of view.

Results of Check			
S		U	

d. MAN HDG mode check out:

(1) Ensure that all switches and controls are in the positions given in Step 2b, and that the heading marker and the bearing pointer are under the upper lubber line.

(2) Place the ISC mode selector to MAN HDG and the Pitch Steer switch to ALT REF.

(3) Rotate the Tacan Bearing synchro dials clockwise and counterclockwise. Result: The bearing pointers on the HSI and BDHI shall follow the movement of the synchro dials.

Note: The synchro closest to the TO-FROM switch controls the movement of the BDHI pointer while the other synchro controls the HSI pointer.

Result of Check			
S		U	

(4) Rotate the Heading Set knob on the HSI clockwise until the heading marker is set to 030 degrees. Result: The vertical steering pointer on the ADI shall indicate a right steering command.

Results of Check			
S		U	

(5) Loosen the silhouette locking knobs and bank the silhouette to the right. Result: This action will cause the vertical steering pointer to move towards its center position. After the vertical steering pointer is centered, rotate the silhouette clockwise (maintaining the correct amount of bank to keep the vertical steering pointer centered) until the heading marker is under the upper lubber line.

Results of Check			
S		U	

(6) Rotate the CADC Altitude Error synchro dial clockwise. Result: The horizontal steering pointer shall indicate a dive command.

Results of Check			
S		U	

e. TKR RV mode check out:

(1) Ensure that all switches and controls are in the positions given in Step 2b, and that the heading marker and bearing pointer are under the upper lubber line.

(2) Place the Pitch Steer switch to the ALT REF position.

(3) Place the ISC mode selector to TKR RV. Result: The Pitch Steer switch will disengage to the OFF position.

Results of Check			
S		U	

(4) Rotate the Tacan Bearing synchro dials clockwise and counterclockwise. Result: The bearing pointers on the HSI and BDHI will follow the movement of the synchro dials.

Note: The BDHI will respond to the synchro dial closest to the TO/FROM switch, and the HSI responds to the other synchro.

Results of Check			
S		U	

(5) Place the Tacan Distance Measuring Valid switch to VALID. Result: The range indicator warning flags on HSI and BDHI shall go out of view.

Results of Check			
S		U	

(6) Rotate the Tacan Distance Measuring synchro dials to the following positions: Hundreds to 1, Tens to 5, Units to 8. Result: The range indicators on the HSI and BDHI shall indicate 158.

Results of Check			
S		U	

(7) Loosen the silhouette locking knobs and rotate the silhouette counterclockwise in azimuth. Result: The ADI and HSI will respond to the movement and show the new heading, and the vertical steering pointer on the ADI shall indicate a right steering command.

Results of Check			
S		U	

(8) Place the silhouette in a right bank. Result: The vertical steering pointer shall center.

Results of Check			
S		U	

(9) Now rotate the silhouette clockwise until the HSI is reading 000 degrees. Result: The ADI and HSI will respond to the movement in azimuth, and the vertical steering pointer on the ADI shall indicate a left steering command.

Results of Check			
S		U	

(10) Return the silhouette to level. Result: The vertical steering pointer on the ADI shall return to center.

Results of Check			
S		U	

(11) Rotate the Target Bearing synchro dial clockwise. Result: The HSI heading marker shall move clockwise the same amount the synchro dial was turned, and the vertical steering pointer on the ADI shall indicate a right steering command.

Results of Check			
S		U	

(12) Place the silhouette in a right bank. Result: The vertical steering pointer will center.

Results of Check			
S		U	

(13) Rotate the silhouette in azimuth until the heading marker is under the upper lubber line. Result: The vertical steering pointer shall indicate a left steering command.

Results of Check			
S		U	

(14) Return the silhouette to level. Result: The vertical steering pointer shall return to center.

Results of Check			
S		U	

(15) Rotate the Pitch/Tilt synchro dial clockwise. Result: The ADI horizontal steering pointer shall indicate a climb command.

Results of Check			
S		U	

(16) Position the silhouette in a NOSE UP attitude. Result: The ADI horizontal steering pointer shall center momentarily then decay to a climb steering command.

Results of Check			
S		U	

(17) Rotate the True Ground Track synchro dial. Result: The HSI course arrow and counter movement shall correspond to the movement of the synchro dial.

Results of Check			
S		U	

(18) Place the silhouette in the level position and secure the locking knobs, and return all switches and controls to the positions given in Step 2b. Now you will begin to troubleshoot the Flight Direct system for malfunctions.

6. TROUBLESHOOTING USING THE PSM-6 MULTIMETER

There are two parts to troubleshooting. (a) Identification of the malfunction and (b) Location of each malfunction using a multimeter.

a. Identification of malfunction: The nine (9) malfunctions placed in each trainer are:

Altitude reference will not engage

Distance unit digit inoperative

Course deviation indicator inoperative

To-From arrow inoperative

Vertical steering pointer in view at all times

Heading marker seeks 30 or 210

Course warning flag in view at all times

Glide slope pointer in view at all times

Horizontal pointer in view at all times

Each of the nine (9) malfunctions must be matched with the correct trouble switch number from the chart on page 20.

(1) Procedure for malfunction identification.

(a) Copy the trouble switch numbers for your trainer (from the chart on page 20) in the left hand column of the chart on page 21.

(2) Place one of the trouble switches to the IN position. (It is important that only one switch be in the IN position at a time.)

(3) Repeat the instructions given for the system operational checks (Section 5) until the correct malfunction is noted.

(4) Record the indicated malfunction on the chart, to the right of the proper switch number.

(5) Place that trouble switch to the OUT position.

(6) Repeat steps 1 through 5 for each of the trouble switches.

TROUBLE SWITCH CHART-FLIGHT DIRECTOR SYSTEM

Trainer Number	01	02	03	04	05	06	07	08	09	10
Trouble Switches To Use	2	2	2	1	1	5	4	4	1	2
	3	4	4	10	2	9*	8*	7*	4	3
	4	7*	6*	11	6*	10	13	10	7	5
	9	8	12	15	8	12	14	11	8	6
	10	12	13	16	9	18	15	20	12	8
	11*	16	14	17*	10	20	19	21	21	12
	18	17	24	18	15	21	22	23	25	13
	21	20	27	29	16	24	24	24	29	20
	30	28	28	30	23	26	26	30	30*	23*

YOUR TRAINER NUMBER __________ YOUR NAME ____________________________________

Sw. #	MALFUNCTION YOU OBSERVED	LOCATION OF MALFUNCTION

b. Location of malfunction using a multimeter. In the following steps you will utilize the Flight Director schematic diagram to determine the cause of each malfunction. Do not analyze the malfunction identified by an asterisk on the trouble switch chart. The procedure to follow in locating the remaining eight (8) malfunctions is:

(1) Analyze the malfunction using Flight Director schematic.

(2) Check your analysis with a PSM-6 multimeter, all checks will be power "ON" voltage checks.

(3) Record the cause of the malfunction and its exact location on the chart provided. An example of your entry should read: open test points 156 and 32. The causes of the malfunctions will be opens, shorts and crossed wires.

Note: This concludes the workbook for those students enrolled in the 3ABR32632B, Integrated Avionic Systems Specialist Course, return all materials to the instructor. Those students in the Avionics Instrument Systems Specialist Course, 3ABR32531, are required to complete the remainder of the workbook.

BENCH CHECK OF THE HSI

During the final portion of this workbook you will use the AN/ASM-159 Flight Director System Component Test Set, an HSI and the operating instructions for the Test Set to bench check the assigned indicator. Read the operating instructions over carefully, then set the controls and monitor the indications specified in the instructions for each section to be tested. Be particularly careful when connecting and disconnecting the cannon plugs so as not to damage the cannon plug pins.

CAUTION: OBSERVE ALL SAFETY PRECAUTIONS.

If you have a problem or do not obtain the specified indications, call your instructor for assistance. Upon completion of the entire check, have your instructor check your answer sheet and sign off the criterion objective before disconnecting the test set and putting it away.

Procedure for using the Flight Director Test Set during bench check.

a. The specific procedures to follow are given in the operating instructions for the Flight Director Test Set.

b. As you complete each part of the Test Set operating instructions, check the responses below and answer them as required.

Part 1. Did the mode lights operate satisfactorily? (Yes-No) If you answered No which lights did not?

Part 2. Did the Distance Counter operate normally? (Yes-No) If you answered No, which part did not?

Part 3. Did the Bearing Pointer operate normally? (Yes-No) If you answered No, what was wrong?

Part 4. Did the Course Pointer operate normally? (Yes-No) If you answered No, what was wrong?

Part 5. Did the Heading Marker operate normally? (Yes-No) If you answered No, what was wrong?

Part 6. Did the Heading Error Signal cause correct movements? (Yes-No)

Part 7. Did the To-From arrow and the Course Deviation Bar operate normally? (Yes-No)

2099

RESPONSE BOOKLET
3ABR32530-1
3ABR32632B
3ABR32531

Technical Training

Automatic Flight Control Systems Specialist
Integrated Avionic Systems Specialist
Avionics Instrument Systems Speciaist

RESPONSE BOOKLET

11 April 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3360 Technical Training Group
Chanute Air Force Base, Illinois

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Instrument/Flight Control Branch
Chanute AFB, Illinois

3ABR32530-1
3ABR32632B
3ABR32531

RESPONSE BOOKLET

This response booklet contains response sheets for the following PTs.

1.	Career Ladder Progression	PT 102 and PT 201
2.	Aircraft Familiarization	PT 103 and PT 202
3.	Avionics Safety	PT 104 and PT 203
4.	Maintenance Fundamentals	PT 105 and PT 204
5.	Aircraft Hardware	PT 105A and PT 204A
6.	Handtools	PT 105B and PT 204B
7.	Special Tools, Safetying Devices, Soldering Techniques & Solderless Connectors	PT 105C and PT 204C
8.	Air Force Technical Order System	PT ATCPT 52-4
9.	AF Supply Discipline	PT 110 and PT 209
10.	Security (COMSEC/OPSEC)	ATC SG E3ABR00001
11.	Security (COMSEC/OPSEC)	ATC SG E3ABR00002
12.	Security (COMSEC/OPSEC)	PT 111 and PT 210

Note: Maintenance Management Volumes I - III response sheets are located in ATCPT 52-1, Volume V.

Supersedes Response Booklet 3ABR32530-1, 8 June 1977.
OPR: 3360 TCHTG
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2209

CAREER LADDER PROGRESSION

Frame 1
a.
b.
c.
d.

Frame 2
a.
b.
c.
d.

Frame 3
a.
b.
c.
d.

Frame 4
a.
b.
c.

Frame 5
a.
b.
c.
d.

Frame 6
a.
b.
c.
d.

Frame 7
a.
b.
c.
d.

Frame 8
a.
b.
c.

Frame 9
1. a.
    b.
    c.
    d.
2. a.
    b.
    c.
    d.
3. a.
    b.
    c.
4. a.
    b.
    c.
5. a.
    b.
    c.

Frame 10
a.
b.
c.

Frame 11
a.
b.
c.
d.

Frame 12
a.
b.
c.

Frame 13
a.
b.
c.
d.

Frame 14
a.
b.
c.
d.

Frame 15
1.
2.
3.
4.
5.
6.
7.

Frame 16
a.
b.
c.

Frame 17
a.
b.
c.

Frame 18
a.
b.
c.
d.

Frame 25

a.

b.

c.

d.

Frame 26

a.

b.

c.

d.

Frame 27

a.

b.

c.

Frame 28

a.

b.

c.

Frame 29

a.

b.

c.

Frame 30

a.

b.

c.

Frame 31

1. a.

b.

c.

2. a.

b.

c.

3. a.

b.

c.

4. a.

b.

c.

5. a.

b.

c.

6. a.

b.

c.

7. a.

b.

c.

8. a.

b.

c.

9. a.

b.

c.

AIRCRAFT FAMILIARIZATION

Frame 1

1.______
2.______
3.______
4.______
5.______

Frame 2

1.______
2.______
3.______

Frame 3

1.______
2.______
3.______

Frame 4

1.______
2.______
3.______
4.______

Frame 5

1.______
2.______
3.______

Frame 6

1.______
2.______
3.______

Frame 7

1.______
2.______
3.______
4.______

Frame 8

1.______
2.______
3.______

Frame 9

1.______
2.______
3.______
4.______

Frame 10

1.______
2.______
3.______
4.______

Frame 11

1.______
2.______
3.______

Frame 12

1.
  a.______
  b.______
  c.______
  d.______

2.
  a.______
  b.______
  c.______
  d.______

3.
  a.______
  b.______
  c.______
  d.______

4.
  a.______
  b.______
  c.______
  d.______

5.
  a.______
  b.______
  c.______
  d.______

Frame 12 (cont.)

6.
  a.______
  b.______
  c.______
  d.______

7.
  a.______
  b.______
  c.______
  d.______

8.
  a.______
  b.______
  c.______
  d.______

Frame 14

1.______
2.______
3.______
4.______
5.______

Frame 15

1. YES/NO

Frame 16

1.______
2.______
3.______

Frame 17

a.______
b.______
c.______
d.______
e.______
f.______
g.______
h.______
i.______
j.______
k.______
l.______
m.______
n.______
o.______

Frame 19

1.
  a.______
  b.______
  c.______
  d.______

Frame 20

1.______
2.______

Frame 22

1. YES/NO

Frame 23

1.
  a.______
  b.______
  c.______
  d.______

Frame 24

1.
  a.______
  b.______
  c.______
  d.______

Frame 25

1.
  a.______
  b.______
  c.______
  d.______

Frame 26

a.______
b.______
c.______
d.______
e.______
f.______

Frame 27

1.
  a.______
  b.______
  c.______
  d.______

2.
  a.______
  b.______
  c.______
  d.______

Frame 28

1.______
2.______
3.______
4.______
5.______

Frame 29

1.______
2.______
3.______

Frame 30

1.
  a.______
  b.______
  c.______
  d.______

2.
  a.______
  b.______
  c.______
  d.______

3.
  a.______
  b.______
  c.______

Frame 31

1.______
2.______
3.______

AIRCRAFT FAMILIARIZATION (Continued)

Frame 32

1.______
2.______
3.______

Frame 36

1.
  a.______
  b.______
  c.______

Frame 37

1.
  a.______
  b.______
  c.______
  d.______

Frame 39

1.______
2.______
3.______
4.______
5.______
6.______
7.______
8.______
9.______
10.______

Frame 40

1.______
2.______

Frame 41

1.______
2.______
3.______

Frame 42

1.______
2.______
3.______

Frame 43

1.______
2.______
3.______

Frame 44

1.______
2.______
3.______

Frame 45

1.______
2.______
3.______
4.______

Frame 47

1.
  a.______
  b.______
  c.______
  d.______

2.
  a.______
  b.______
  c.______
  d.______

AVIONICS SAFETY

Frame 1
1.
2.
3.
4.
Frame 2
1.
2.
3.
4.
Frame 3
1.
2.
3.
4.
Frame 4
1.
2.
3.
Frame 5
1.
2.
3.
Frame 6
1.
2.
3.

Frame 7
1.
2.
3.
Frame 8
1.
2.
3.
4.
Frame 9
1.
2.
3.
Frame 10
1.
2.
3.
Frame 11
1.
2.
3.
Frame 12
1.
2.
3.

Frame 13
1.
2.
3.
Frame 14
1.
2.
Frame 15
NO RESPONSE
Frame 16
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.

Frame 17
1.
2.
3.
Frame 18
NO RESPONSE
Frame 19
1.
2.
3.
Frame 20
1.
2.
3.
Frame 21
1.
2.
3.
Frame 22
1.
2.
3.
4.
Frame 23
1.
2.
3.

Frame 24
1.
2.
3.
Frame 25
1.
2.
3.
Frame 26
1.
2.
3.
4.
Frame 27
1.
2.
3.
Frame 28
1.
2.
Frame 29
1.
2.
3.

2106

AVIONICS SAFETY (Continued)

Frame 30

1.

2.

3.

Frame 31

1.

2.

3.

Frame 32

1.

2.

3.

Frame 33

1.

2.

3.

Frame 34

1.

2.

3.

Frame 35

NO RESPONSE

Frame 36

1.
2.
3.
4.
5.
6.
7.
8.

Frame 36 (Cont.)

9.
10.
11.
12.
13.
14.

Frame 37

1.

2.

3.

Frame 38

1.

2.

3.

Frame 39

1.

2.

3.

Frame 40

1.

2.

3.

Frame 41

1.

2.

3.

Frame 42

1.

2.

3.

4.

Frame 43

1.

2.

3.

Frame 44

1.____________

____

2.____________

____

3.____________

____

Frame 45

____

____

Frame 46

____

____

____

____

Frame 47

NO RESPONSE

Frame 48

____

____

____

Frame 49

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

Frame 50

1.

2.

3.

4.

Frame 51

1.

2.

3.

Frame 52

1.

2.

3.

4.

Frame 53

____

____

____

Frame 54

a.

b.

c.

d.

e.

AVIONICS MAINTENANCE FUNDAMENTALS

Frame 1:

a.
b.
c.
d.

Frame 2:

a.
b.
c.

Frame 3:

a.
b.
c.

Frame 4:

a.
b.
c.

Frame 5:

a.
b.
c.

Frame 6:

a.
b.
c.

Frame 7:

a.
b.
c.

Frame 8:

a.
b.
c.
d.

Frame 9:

a.
b.
c.
d.

Frame 10:

a.
b.
c.

Frame 11:

a.
b.
c.

Frame 12:

a.
b.
c.

Frame 13:

a.
b.

Frame 14:

a.
b.
c.
d.
e.
f.

Frame 15:

No response

Frame 16:

No response

Frame 17:

a.
b.
c.
d.

Frame 18:

a.
b.
c.
d.

Frame 19:

a.
b.
c.

Frame 20:

1. a.
b.
c.

2. a.
b.
c.

3. a.
b.
c.

4. a.
b.
c.

5. a.
b.
c.

6. a.
b.
c.

7. a.
b.
c.

Frame 20(cont)

8. a.
b.
c.

9. a.
b.
c.
d.

10. a.
b.
c.

11. a.
b.
c.
d.

Frame 21:

1.________
2.________
3.________

Frame 22:

1.________
2.________
3.________

Frame 23:

1.________
2.________
3.________

Frame 24:

1._____ 2._____
3._____ 4._____
5._____

Frame 25:

No response

Frame 26:

1.________
2.________

Frame 27:

1.________
2.________
3.________

Frame 28:

1.________
2.________
3.________

Frame 29:

No response

Frame 30:

1.________
2.________
3.________
4.________

Frame 31:

1.________
2.________

Frame 32:

1.________
2.________ 3._____

2108

Frame 33:

No response

Frame 34:

1.______

2.______

3.______

Frame 35:

1.______

2.______

3.______

Frame 36.

1.______

2.______

3.______

Frame 37:

1.______

2.______

Frame 38:

1.______

2.______

3.______

Frame 39:

1.______

2.______

3.______

4.______

5.______

Frame 40:

1.___ 2.___

Frame 41:

1.______

2.______

3.______

Frame 42:

1.______

2.______

Frame 43:

1.______

2.______

3.______

4.______

Frame 44:

No response

AIRCRAFT HARDWARE

Frame 1
1.
2.

Frame 2
1.
2.

Frame 3
1.
2.
3.
4.

Frame 4
1.
2.

Frame 5
a.
b.
c.
d.

Frame 6
No Response

Frame 7
1.
2.

Frame 8
1.
2.
3.
4.

Frame 9
1.
2.
3.
4.
5.

Frame 10
No Response

Frame 11
1.
2.

Frame 12
a.
b.
c.
d.

Frame 13
1.
2.

Frame 14
a.
b.
c.
d.

Frame 15
1.
2.
3.
4.

Frame 16
a.
b.

Frame 17
1. a.
  b.
  c.
  d.
2. a.
  b.
  c.
  d.
3. a.
  b.
  c.
  d.

Frame 17(cont)
4. a.
  b.
  c.
  d.

Frame 18
a.
b.
c.

Frame 19
1.
2.

Frame 20
1.
2.
3.

Frame 21
a.
b.
c.
d.

Frame 22
1.
2.
3.
4.

Frame 23
1.
2.
3.

Frame 24
a.
b.
c.
d.

Frame 25
a.
b.
c.
d.

Frame 26
a.
b.
c.
d.

Frame 27
No Response

Frame 28
a.
b.
c.
d.

Frame 29
1.
2.
3.
4. a.
  b.
  c.
  d.

Frame 30
No Response

Frame 31
1.

Frame 32
1.
2.
3.
4.
5.

Frame 33
1.
2.

Frame 34
1.
2.
3. a.
  b.
  c.
  d.

AIRCRAFT HARDWARE (Continued)

Frame 34 (cont)

4. a.
   b.
   c.
   d.
5.
6.
7.
8.

Frame 35

1.
2.
3.
4.

Frame 36

1.
2.
3.
4.

Frame 37

1.
2.
3.
4.

Frame 38

No Response

Frame 39

1.
2.

Frame 40

No Response

Frame 41

1.
2.
3.
4.

Frame 42

1.
2.
3.
4.

Frame 43

1.
2.
3.
4.
5.
6.

Frame 44

1.
2.
3.
4.
5.
6.

Frame 45

1.
2.
3.
4.
5.
6.
7.
8.

Frame 46

1.
2.
3.
4.

Frame 47

1.
2.
3.

Frame 48

No Response

Frame 49

1. a.
   b.
   c.
   d.

Frame 50

1. a.
   b.
   c.
   d.

Frame 51

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.

2111

HANDTOOLS

Frame 1
NO RESPONSE
Frame 2
1.__________
2.__________
Frame 3
1.
2.
3.
Frame 4
1.
2.
3.
Frame 5
1.
2.
3.
4.
Frame 6
1.
2.
3.
Frame 7
1.
2.
3.
4.

Frame 8
1.
2.
3.
Frame 9
1.
2.
Frame 10
1.
2.
Frame 11
1.
2.
3.
Frame 12
1.
2.
3.
4.
Frame 13
1.
2.
3.
Frame 14
1.
2.
3.

Frame 15
1.
2.
3.
Frame 16
1.
2.
Frame 17
1.
2.
3.
Frame 18
1.
2.
3.
Frame 19
1.
2.
3.
Frame 20
1.
2.
Frame 21
1.
2.
3.

Frame 22
1.
2.
Frame 23
1.
2.
Frame 24
1.
2.
Frame 25
1.
2.
3.
Frame 26
1.
2.
3.
4.
Frame 27
1.
2.
3.
Frame 28
1.
2.
3.

Frame 29
1.
2.
3.
Frame 30
1.
2.
3.
Frame 31
1.
2.
3.
Frame 32
1.
2.
3.
Frame 33
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Frame 33 (CONT)
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.
31.
32.

2120

SPECIAL TOOLS, SAFETYING DEVICES, SOLDERING TECHNIQUES AND SOLDERLESS CONNECTORS

(PART A)

Frame 1
a.
b.
c.
d.

Frame 2
a.
b.
c.
d.

Frame 3
a.
b.
c.
d.

Frame 4
a.
b.
c.
d.

Frame 5
a.
b.
c.
d.

Frame 6
a.
b.
c.

Frame 7
a.
b.
c.

Frame 8
1.________
2.________
3.________
4.________
5.________

Frame 9
a.
b.
c.
d.

Frame 10
a.
b.
c.
d.

Frame 11
a.
b.
c.

Frame 12
a.
b.
c.
d.

Frame 13
NO RESPONSE

SAFETYING DEVICES
PART B

Frame 14
NO RESPONSE

Frame 15
a.
b.
c.
d.

Frame 16
1.a.
   b.
   c.
   d.
2.a.
   b.
   c.
   d.

Frame 17
1. a.
   b.
   c.
   d.

2. a.
   b.
   c.
   d.

3. a.
   b.
   c.
   d.

4. a.
   b.
   c.
   d.

Frame 18
a.
b.
c.
d.
e.

Frame 19
a.
b.
c.
d.

Frame 20
1.
2.

Frame 21
1. a.
   b.
   c.
   d.
2. a.
   b.
   c.
   d.

Frame 21
3. a.
   b.
   c.
   d.

4. a.
   b.
   c.
   d.

SOLDERING TECH.
& SOLDERLESS
CONNECTORS
PART C

Frame 22
NO RESPONSE

Frame 23
1.
2.
3.
4.

Frame 24
1.
2.
3.
4.

Frame 25
1.
2.
3.

Frame 26
1.
2.
3.
4.

Frame 27
1.
2.
3.
4.

Frame 28
1.
2.
3.
4.

Frame 29
NO RESPONSE

Frame 30
1.
2.
3.

Frame 31
1.
2.
3.
4.

Frame 32

____

Frame 33
1. a.
   b.
   c.
   d.
2. a.
   b.
   c.
   d.
3. a.
   b.
   c.
   d.
4. a.
   b.
   c.
   d.
5. a.
   b.
   c.
   d.
6. a.
   b.
   c.
   d.
7. a.
   b.
   c.
   d.

SPECIAL TOOLS, SAFETYING DEVICES, SOLDERING TECHNIQUES, AND SOLDERLESS CONNECTORS

(LAB SHEET)

Special Tools
Part A

1. No Response

2. a.__________

3. a.__________

b.__________

4. No Response

5. a.__________

6. a.__________

7. a.__________

8. a.__________

The rest of the responses are PERFORMANCE ONLY.

Safetying Devices
Part B, Section A

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.

Section B

1.
2.
3.
4.
5.
6.
7.

Section C

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.

Section D
Fig. A

1.
2.
3.
4.
5.

Section D
Fig. B

1.
2.
3.
4.
5.

Soldering Techniques and
Solderless Connectors
Part C

Exercise I

a. (1)__________

b. (1)__________

(2)__________

(3)__________

c. Performance

d. Performance

e. (1) __________

(2)__________

(3) Performance

f. (1) Performance

(2) Performance

(3) Performance

Exercise II and III are both performance

Exercise IV

1. a. (1)__________

b. (1)__________

The remainder of exercise IV is all performance.

2114

ATCPT 52-4
dtd June 1977

ANSWER SHEET

AIR FORCE TECHNICAL ORDER SYSTEM

1. a.
b.
c.
d.

2. a. ____________
____
b. ____________
____
c. ____________
____

3. a.
b.
c.
d.
e.

4. a.
b.
c.
d.
e.
f.

5. a.
b.
c.
d.
e.

6. a.
b.
c.
d.
e.
f.

7. AFM 66-1
TO 00-5-1
AFR 5-2
AFTO Form 210
AFVA 39-18
TO 1B-52G-1

8. 1. a.
b.
c.
d.
e.
f.

2. a.
b.
c.
d.
e.

3. b.
c.
d.
e.
f.
g.
h.

9. a. ________
d. ________

10. a.
b.
c.
d.
e.
f.
g.

11. __ a. ________
__ b. ________
__ c. ________
__ d. ________

12. ____________

13. a.
b.
c.
d.
e.
f.
g.
h.
i.

14. a.
b.
c.

15. a. ________
b. ________
c. ________

16. a.
b.
c.
d.

17. a. ________________
b. ________________
c. ________________
d. ________________

18. a. ________________
b. ________________
c. ________________
d. ________________
e. ________________
f. ________________

19. a.
b.
c.
d.
e.
f.
g.

20. a.
b.
c.
d.

2223

2115

AIR FORCE TECHNICAL ORDER SYSTEM (Continued)

21. ______1.
______2.
______3.
______4.
______5.
______6.
______7.

22. a.
b.
c.
d.
e.
f.
g.
h.

23. 1.__________
2.__________
3.__________

24. a.
b.
c.
d.
e.

25. __________a.
__________b.
__________c.
__________d.
__________e.

26. a.
b.
c.
d.
e.
f.
g.
h.
i.
j.

27. ___1.
___2.
___3.
___4.
___5.

28. a.
b.
c.
d.

29. a.
b.
c.
d.

30. a.
b.
c.
d.
e.
f.

31. ___1.
___4.
___5.
___7.
___8.

33. a.
b.
c.
d.
e.
f.

34. a.
b.
c.
d.
e.
f.
g.

35. ___1.
___2.
___3.
___4.
___5.
___6.

36. a.
b.
c.
d.

37. a.
b.
c.
d.

38. a. (1) ____________
(2) ____________
OR ____________
b. ______________
____

39. ____________________

40. a.
b.
c.
d.
e.

41. a.
b.
c.

42. ___1.
___2.
___3.
___4.
___5.
___6.
___7.
___8.

43. ____________________

44. ____________________
____

2224

45. a.____________

b.____________

____

c.____________

____

46. a.
b.
c.
d.
e.

47.____________

____

48. ___a.

___b.

___c.

___d.

___e.

49. a.____________

b.____________

c.____________

50. a.____________

b.____________

c.____________

51. ___1.

___2.

___3.

52. a.____________

____

b.____________

____

c.____________

____

53. a.
b.
c.
d.
e.
f.
g.

54. a.
b.
c.
d.

55. a.
b.
c.
d.
e.
f.

56. a.
b.
c.
d.

57. a.
b.
c.

58. a.
b.

59. a.____________

b.____________

60. a.____________

b.____________

62. a.

b.

63. a.____________

b.____________

c.____________

64. a.____________

b.____________

c____________

65. a.____________

____

____

b.____________

____

____

c.____________

____

____

d.____________

____

____

e.____________

____

____

f.____________

____

____

66. ____a.

____b.

____c.

____d.

____e.

____f.

____g.

____h.

____i.

____j.

67. a. ________
b. ________
a. ________
b. ________

68. ____a.
_____b.
____c.

69. ____a.
____b.

70. ____________

71. a. ________
b. ________
c. ________
d. ________
e. ________
f. ________
g. ________
h. ________
i. ________
j. ________

72. a.
c.
d.
e.
g.
h.
i.

73. ___ 1.
____2.
___ 3.

73.cont.
___ 4.
___5.
___ 6.
___ 7.

74. ___a.
___b.
___c.
___d.
____e.

75. ___ a.
___ b.
___ c.
___d.
___ e.

76. ___ 1. ________
___ 2. ________
___ 3. ________
___ 4. ________
___ 5. ________
___ 6. ________
____ 7. ________
___ 8. ________

77. a.
b.
c.
d.
e.

78. a.
b.
c.
d.
e.
f.

79. a.
b.
c.
d.
e.
f.

80. a.
b.
c.
d.

81. ____________
____
____
____
____

82. ____________
____
____
____

83. ____________
____
____
____
____
____
____

84. 1.
    2.

85. ______

    ______

86. a. ______

    b. ______

87. ______

88. ______

89. ______

90. ______

91. ______ ______

    ______ ______

    ______ ______

    ______ ______

92. a. ______

    b. ______

    c. ______

93. ______ ______

    ______ ______

94. a.
    b.
    c.
    d.
    e.

95. a.
    b.
    c.
    d.

96. a.
    b.
    c.

97. a. ______

    b. ______

98. a.
    b.
    c.
    d.
    e.
    f.
    g.

99. a. ______

    b. ______

100. a. ______

     b. ______

101. a. ______

     b. ______

     c. ______

102. a. ______

     b. ______

     c. ______

103. ______

104. 1. ______

     2. ______

     3. ______

     4. ______

     5. ______

     6. ______

     7. ______

     9. ______

105. 6. ______
     7. ______
     8. ______
     9. ______
     10. ______
     11. ______
     12. ______
     13. ______
     14. ______
     15. ______
     16. ______
     17. ______
     18. ______
     19. ______
     20. ______
     21. ______
     22. ______
     23. ______
     24. ______

106. a.
     b.
     c.
     d.

107. a.
     b.
     c.
     d.

107. a.
     b.
     c.
     d.

108. a. ______

     b. ______ ______ ______

     c. ______

109. a. ______

     b. ______

     c. ______

     d. ______

110. a.__________

b.__________

____

____

c.__________

d.__________

e.__________

111. a.
b.
c.
d.

112. a.
b.
c.
d.

113. a.
b.
c.
d.
e.

114. ____1.
____2.
____3.
____4.
____5.

115.a.__________

b.__________

116.a.___ ___

b.___ ___

117.a.___ ___ ___ ___

b.___ ___ ___ ___

118.a.___ ___ ___ ___

b.___ ___ ___ ___

119. ___a.
___b.
___c.
___d.
___e.
___f.

120. 1.__________

2.__________

3.__________

4.__________

5.__________

121. a.
b.
c.
d.

122. 1.____ ____

2.____ ____

3.____ ____

4.____ ____

123. 1.___ ___ ___

2.___ ___ ___

3.___ ___ ___

4.___ ___ ___

5.___ ___ ___

124. 1.___ ___ ___ ___

2.___ ___ ___ ___

3.___ ___ ___ ___

4.___ ___ ___ ___

5.___ ___ ___ ___

6.___ ___ ___ ___

7.___ ___ ___ ___

125. 1.___ ___ ___ ___ ___

2.___ ___ ___ ___ ___

3.___ ___ ___ ___ ___

4.___ ___ ___ ___ ___

5.___ ___ ___ ___ ___

6.___ ___ ___ ___ ___

7.___ ___ ___ ___ ___

8.___ ___ ___ ___ ___

126. 1.______________

2.______________

3.______________

4.______________

5.______________

127. 1.___ ___ ___ ___ ___

2.___ ___ ___ ___ ___

3.___ ___ ___ ___ ___

4.___ ___ ___ ___ ___

5.___ ___ ___ ___ ___

6.___ ___ ___ ___ ___

7.___ ___ ___ ___ ___

8.___ ___ ___ ___ ___

128. 1.______________

2.______________

3.______________

4.______________

129. a.
b.
c.
d.

130. 1.___ ___

2.___ ___

3.___ ___

4.___ ___

131. 1.___ ___ ___ ___

2.___ ___ ___ ___

3.___ ___ ___ ___

4.___ ___ ___ ___

5.___ ___ ___ ___

132. 1.___ ___ ___ ___

2.___ ___ ___ ___

3.___ ___ ___ ___

4.___ ___ ___ ___

5.___ ___ ___ ___

6.___ ___ ___ ___

133. 1.______________

2.______________

3.______________

4.______________

134. 1.___ ___ ___ ___

2.___ ___ ___ ___

3.___ ___ ___ ___

4.___ ___ ___ ___

5.___ ___ ___ ___

6.___ ___ ___ ___